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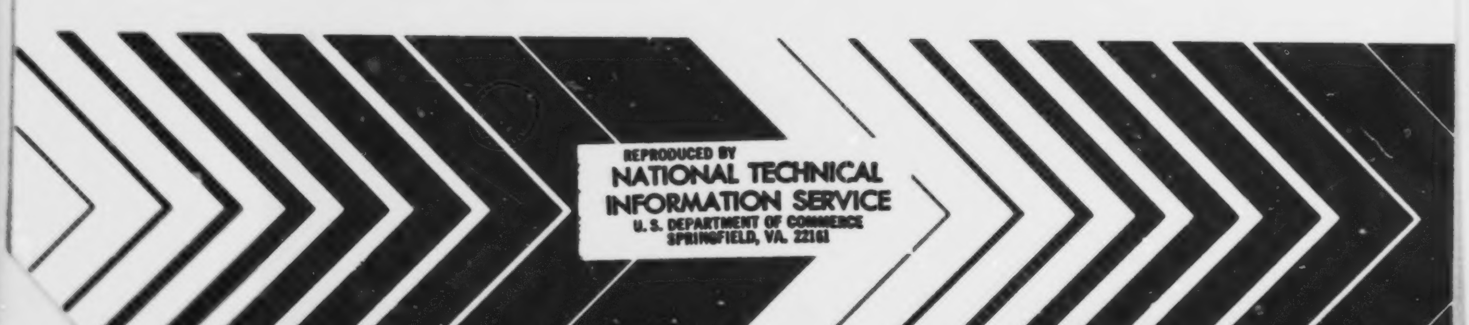

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16. ABSTRACT

A basic proposition of economic theory is that when the price of a good increases, other things being equal, the quantity of that good purchased will decrease. For some time now, economists have suggested that this relationship between price and quantity should be considered by policymakers and solid waste managers for efficient management of solid waste. The effects of pricing (e.g. changes in quantity, composition of the waste collected, impacts on resource recovery, litter, and economic efficiency) have never been fully investigated.

Empirical results from five (5) communities having several forms of user charges are presented. The results suggest that household demand for various levels of collection services are sensitive to price but that the quantity of waste that households set out for collection and disposal may not be sensitive to price. These results must be considered tentative because of data problems and critical assumptions that had to be made. Additional studies are needed before firm conclusions can be made about user charges.

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IMPACT OF USER CHARGES ON MANAGEMENT OF HOUSEHOLD SOLID WASTE

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

User charges for financing the collection and disposal of municipal solid waste are used by a number of communities in the United States. Interest in user charges has been growing because of increasing public resistance to property taxes--the traditional way of financing the solid waste service. There is a lack of information, however, on whether such charges or fees produce net social benefits. The effects of incremental charges on the quality and quantity of collected residential solid waste, litter, resource recovery and economic efficiency have never been fully evaluated. The research reported here represents an initial attempt at answering some of the questions raised by local community leaders and managers concerning user charges for management of solid waste. These results should be considered preliminary as additional studies are needed before conclusions and recommendations can be made about the economic efficiency of user charges.

Francis T. Mayo
Director
Municipal Environmental Research
Laboratory

ABSTRACT

A basic proposition of economic theory is that when the price of a good increases, other things being equal, the quantity of that good demanded will decrease. Economists have suggested that this relationship between price and quantity demanded could be used by solid waste managers as a tool for efficient management of household solid waste.

This study presents empirical evidence from five selected communities with various charge structures for solid waste collection and disposal. It suggests that although household choices between types or levels of collection and disposal services may be sensitive to price, the total quantity of waste generated by households may not be sensitive to price. It also suggests that quantity of waste increases with household income at a rate consistent with that found by other studies.

This report was submitted in fulfillment of Contract No. 68-03-2634 by MATHTECH, Inc. under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from November 1, 1977 to February 1, 1979, and work was completed as of May 16, 1979.

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SECTION 1

INTRODUCTION

Various strategies for collection of residential household solid waste have been developed over the years in an attempt to provide efficient solid waste collection and disposal services. As our understanding of environmental problems associated with solid waste has evolved, the operational concept of efficiency has also changed to encompass a broader meaning than that of minimizing collection and disposal costs.

Demand for solid waste collection and disposal, like economic demand for any service, is affected by its price relative to the prices of other goods and services. As household cost rises, demand for "conventional" waste disposal falls. This is reflected both in a decline in waste generation and in increased use of other disposal methods such as littering and self-hauling. Also, as with many other goods and services, the consumption of solid waste disposal services leads to the imposition of costs on third parties. These external costs are often not reflected in prices paid by individual households.

The qualitative effects on households that result from imposition of (or an increase in) service charges or changes in quality of service can be developed from economic theory. Similarly, the cost of collection/disposal systems can be determined from engineering data. However, the quantitative effects of service user charges on behavior of households are not yet well understood. While it is important to recognize that the imposition of a charge will probably result in increased littering, for example, it is also necessary to understand the quantitative relationships between charges and patterns of household waste generation and disposal in order to provide guidelines for setting prices in a way that approaches system efficiency.

This report contains the results of case studies of the use of user charges for collection and disposal of household solid waste in selected communities. The project was comprised of five tasks: to develop a descriptive list of communities employing a user charge system for household solid waste collection and disposal; to group these communities into general categories of user charge systems and to select one example from each category for case study; to carry out case studies and collect data on the operation of the user charge system in each city investigated; to make an empirical analysis of these data regarding the effects of each type of user charge system studied; and to report the conclusions of this analysis.

In completing the first three of these tasks we first made an exhaustive search of previous empirical studies of solid waste management systems in order to compile what we believe to be the most extensive list to date of U.S. cities employing user charges. This list appears in Appendix A of this report. We next grouped these cities into five categories according to the type of user charge employed: flat-fee systems, container-based (or capacity-based) systems, location-based (or service-based) systems, metered-bag (or quantity-based) systems, and systems involving combinations of the first four. Finally, we conducted case studies of cities which employ each of these types of systems: Burbank, California; Sacramento, California; Grand Rapids, Michigan; Provo, Utah; and Tacoma, Washington.

Subsequent sections of this report contain conclusions of our analysis of data from the case studies, recommendations based on these conclusions, a review of the literature on and development of econometric models of user charge systems, and the results, data, and description of the case studies.

SECTION 2

CONCLUSIONS

Two principal conclusions emerge from analysis of the user charge systems studied in this project: first, demand for household solid waste service, in most cases, seems to be highly inelastic with respect to price; and second, interaction between households and solid waste management systems is considerably more complex than a simple supply-and-demand model might indicate. On the face of it, our findings of price elasticities not significantly different from zero conflict with what has often been assumed in theoretical discussions of user charges as well as with some earlier empirical findings. Although the observations we report come from only five cities, they demonstrate that managerial decisions to institute or to modify user charges take place in social, political, and technological contexts which may influence decisions more strongly than narrowly conceived economic considerations. While this does not affect theoretical questions of the efficiency of user charges, it is important to the solid waste manager who must decide whether to implement such a system or to modify an existing one.

EFFECTS ON DEMAND

A fundamental proposition of economic theory is that for any good the quantity demanded declines as price increases. If this is true of demand for solid waste services, then certain responses in household behavior can be expected under a user charge regime where prices vary according to quantity of service received. First, when the price of solid waste service increases, households are expected to demand less service. If price varies according to quantity of waste presented for collection, a price increase is expected to result in presentation of less waste; if price varies according to some other service component, a price increase is expected to reduce demand for that component. We shall later show that an increase in price of a non-quantity service component is also expected to result in presentation of less waste. Second, when the price of solid waste service increases, households are expected to alter their behavior regarding waste generation and disposal. Household waste generation is affected because an increase in the price of service reduces income available for expenditure on waste-generating goods, although these goods become less expensive relative to the price of solid waste service. Of course, so long as the price of service is a very small portion of income, the magnitude of the resulting income and substitution effects are negligible. Household waste disposal practices are affected because households have a choice between presenting waste for collection and disposing of waste by alternative methods. They often have additional choices between levels or types of collection service and between self-disposal methods which may be socially costly (e.g., littering) or not (e.g., self-hauling). A price increase is expected to result in an increase in quantity of waste self-disposed and in a decrease in quantity of expensive types of collection demanded. And third, households are supposed to adjust their behavior so as to equate the marginal utility of various goods, which has the effect of efficiently allocating resources to and between solid waste services if their prices are equal to their marginal social costs.

Various elasticities of demand are relevant to the foregoing description of household behavior. These elasticities express how the choices made by households are related to factors over which they have far less control, such as income and prices of solid waste service. In three cities (Burbank, Sacramento, and Grand Rapids) we found significant[1] income elasticities consistent with previous findings (.22, .20, and .40, respectively), and in Provo we found indirect evidence of positive income elasticity. This indicates that solid waste service is a normal good for which demand increases with, but not as fast as, income. We found no evidence of significant price elasticity. Burbank employs a flat fee structure, so we would not expect price elasticity there, since the marginal price of service is zero. Adequate data for estimation of price elasticities were not available in Provo, where price varies according to service level. Grand Rapids and Sacramento employ fee structures which vary according to quantity presented for collection. In neither of these cities did we find price elasticities significantly different from zero. In Tacoma, where price varies according to both quantity presented and level of service demanded, we found that although significant price elasticities for number of containers selected and for level of service exist, price elasticity for quantity of waste generated is not significantly different from zero. This seeming paradox may be explained by recalling that self-hauling is a readily available substitute for collection service in Tacoma.

These findings suggest that for the price levels we observed, quantity of service demanded, and hence quantity of waste presented for collection, is highly inelastic. This suggested conclusion must be qualified by noting that any statistical test is a joint test of the adequacy of the model and the parameters tested. Because we rely on data collected for other purposes and employ surrogates for unavailable data, the presence of measurement error must be considered likely. Further, the extent to which relevant variables are omitted and functional forms are presumed raises the possibility of specification error. Therefore, our findings are consistent either with there being no price effect on waste generation or with statistical problems masking the true effect. Three to five cities is not a large sample, but those we studied did provide a great deal of variety of types of data. It is therefore interesting that the finding of no price effect on quantity is so uniform.

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[1] Throughout this report we test hypotheses about elasticity at the 95% level. That is, a finding of significant elasticity indicates a probability of less than 5% that elasticity is in fact zero. In some places a different level of significance is additionally indicated (e.g., "significant at the 80% level," etc.). Caution should be taken in interpreting the latter figures, of course, because if the level of significance is chosen after regression results are known, then all elasticities are significant at some level and hence no hypothesis about significance has been tested.

One simple theory of economic behavior which might account for price inelasticity of demand for solid waste services would be to invoke the joint product aspect of solid waste and the time separation of consumption decisions affecting solid waste generation and disposal. Most household solid waste originates as a joint product of goods consumed by households in the form of packaging, for example. This means that the decision to generate waste is made simultaneously with the decision to consume goods and services other than waste collection. Not only is the price of collection of the waste component of most goods very small in comparison to the price of the good, but also household decisions about how to dispose of waste are separated in time from decisions affecting how and in what quantity waste is generated. Testing hypotheses which follow from this theory addresses questions related to product charges rather than user charges. However, this may be an area which warrants further study.

EFFECTS ON COST

The main effect of user charges on the cost of solid waste collection is the addition of billing and collection costs. Savas, Baumol, and Wells (1976) [1] estimate billing costs at 3.1% of total collection costs based on a sample of 39 cities with municipal collection and user charges. Our findings concur with this figure. In four of the five cities we studied residents are billed for collection together with electric and/or water and sewage bills. The fifth city, Grand Rapids, employs a metered-bag system, which involves no billing costs, but retail distributors, who account for 62% of revenues, are allowed to keep 4% of their sales receipts, and there are costs from maintaining stocks as well as costs of refuse bags and tags. The cost of tags is about 3% of their retail price; on the assumption that 97% of the price of tags constitutes payment for service and that 97% of the price of bags constitutes payment for service plus the value of the bag, the ratio of "billing" to total cost of collection in Grand Rapids is about 5.5% (.03 + .04 x .62). In Provo, billing appears to constitute about 3.2% of the price of residential collection, and in Tacoma billing and collection is about 3.4% of total collection expenses. No estimate of billing costs was available in Burbank or Sacramento.

It is sometimes argued that the ratio of collection cost per household to user fee is much nearer unity in user charge cities with contract collection than in user charge cities with municipal collection. Such arguments speculate that this is because cities with contract collection know how much collection costs, while cities with municipal collection do not. Our study considered only cities with municipal collection; we found great disparities in the amount of cost information available, although it is not clear that these are related to the type of user fee employed or to the presence of municipal collection. In three of the five cities we visited — Provo, Burbank, and Sacramento -- almost no information was available about costs apart from items in the annual budget. In particular, since costs and revenues from residential and commercial collection were not available separately, there was no way to estimate ratios from household collection. Rather more detailed accounts were available in Grand Rapids, aided by the fact that there is no municipal collection of commercial waste in that city, and the cost accounting procedures in Tacoma were found to be excellent for our purposes as well as those of the solid waste manager. In Grand Rapids the ratio of collection cost to user charge is 2.22; in Tacoma the ratio is .96. It is doubtful, however, that the difference between these two cities is due entirely to differences in knowledge or record-keeping. User charges in Grand Rapids are not intended as the exclusive means of financing collection; they are in Tacoma. The performance of Tacoma's collection system matches the ideal of a contract collector who balances his budgets, despite its having municipal collection. It is also worth mentioning that both Sacramento and Burbank had contract collection immediately before they instituted municipal collection, but found the arrangement unsatisfactory. In Grand Rapids the city government proposed contract collection in 1972, only to have the proposal defeated in a referendum.

Finally, it is sometimes said that one cost effect of user charges under a municipal regime is that households may pay more because user charges, unlike city tax, cannot be deducted from Federal income tax. In part this depends on answers to empirical questions that can be ascertained for individual cities only by knowing income distribution, land ownership patterns, and local tax structures for which we lack data in the cities under study. But in part it also raises questions of the equity of user charges, a subject beyond the scope of this study.

SOCIAL AND POLITICAL ISSUES

It appears, then, that user charges in and of themselves may not have the economic effects, in the narrow sense, traditionally associated with market institutions. Quantity of solid waste produced is highly inelastic with respect to incremental pricing, although other services, such as carryout service, act as normal goods with price elasticities of around 0.3. Consequently, the littering effect of user charges is nil. On the supply side of the market, user charges appear to be instruments of financial or social policy which may be used in conjunction with other techniques to minimize costs, but do not necessarily have this effect. We shall now look at some broader considerations which we feel are important as pointing to areas of further investigation.

The presence of user charges for solid waste collection is associated with an ideological commitment to the judgment that individuals should "pay for what they get," as opposed to the notion that solid waste collection is a public good to be paid for jointly through general taxation. Solid waste personnel offered this idea as an explanation for why collection was financed through user charges in every city we visited. In terms of financial structures, both Provo and Grand Rapids budget solid waste departments as enterprise funds which stand separate from other municipal agencies; in Tacoma the department is a classified utility, indicating an even greater autonomy. Thus there is an effort to make the solid waste system as much like private business as possible within the confines of government; user charges lend credibility to this effort. Note, however, that although consideration has on occasion been given to going over to private collection in each of these cities, the single instance in which this was seriously attempted -- Grand Rapids -- resulted in voter rejection. Paradoxically, the opponents of contract collection in that referendum claimed that it would have been tantamount to socialism because it would have excluded private haulers who lacked franchises.

We observed several instances in which the adoption of a particular fee structure brought unexpected problems due to constraints of a political or technological nature often quite independent of market factors. The prime example of this is the effect of the 1974 oil embargo which cut the supply of plastic bags in Grand Rapids, resulting in the substitution of collection tags and ultimately the present combination of the two. This could only occur with a metered-bag system. Prior to that, the adoption of a metered-bag system in the first place was the logical consequence of the referendum we have alluded to, an episode described in Section 8. Where user fees vary according to number of containers, as in Sacramento and Tacoma, households sometimes leave extra garbage alongside but not in containers. Metered bags are the obvious solution to this problem, but a metered-bag system cannot easily be operated in conjunction with carryout service, which Tacoma has. In Section 9 we discuss how this problem was resolved there. Problems may arise when political decision-makers come into conflict with solid waste managers, as in Provo, where collection personnel would like to eliminate carryout service, but elected officials regard the service (perhaps erroneously) as benefitting the aged and invalid and hence a matter of social policy. In most of the cities we studied we found evidence of modifications of fee structures (in addition to price changes) from time to time. User charges seem to facilitate this process, which from the consumers' point of view amounts to modifying the range of choices available. This was especially true of Tacoma and Grand Rapids, whose systems offer the broadest range of choices; true to a lesser degree in Sacramento and Provo, whose structures are less complex; and least true in Burbank, whose fee structure is simplest. On the other hand, complex fee structures may be difficult to modify dramatically. In both Tacoma and Grand Rapids certain experimental changes have been considered and rejected because of uncertainty about their effect. Finally, the passage of Proposition 13 in California may well make user charges more attractive to municipalities in that state who do not have them, and lead to closer scrutiny of the levels at which fees are set among those who do. All of these observations point to issues that managerial and political officeholders should be aware of when contemplating user charges.

Although we indicated above that user charges may have little effect on illicit disposal which would increase overall system costs, we feel there may be an indirect relation between user charges and littering, as well as between user charges and resource recovery. Each city we studied has felt the impact of such changes in legal constraints as restrictions on disposal techniques and waste burning by households. Tacoma experienced a 70% increase in the quantity of waste (legally) self-hauled from 1968 to 1969, after Washington's environmental law took effect. Sacramento hauls more yard waste now that private burning is illegal. Tacoma has built a $2.4 million resource recovery facility which will eventually recycle 80% of its disposal-site waste, and Provo is considering a similar program on a more modest scale. In these cases there did not appear to be a direct link between the existence of user charges and the programs. In Grand Rapids, however, a clear link was present. Because the city must compete with private haulers for customers, and because the sale of metered bags is a source of revenue, the Environmental Protection Department has become involved in a marketing effort. This has benefited relations between the Department and shopkeepers on the one hand, since their cooperation is necessary for the sale of metered bags, and with the public on the other, who are informed about the availability of bags, clean-up drives, and other facilities through what amounts to an advertising campaign.

For the most part it is difficult to relate the foregoing observations to particular fee structures, but one generalization that seems warranted is that the amount of information available to solid waste managers and other decision-makers increases with the complexity of fee structure. If complexity is loosely defined in terms of the number of choices typically available to households, Burbank is the least complex of our cities, followed by Provo, Sacramento, Grand Rapids, and Tacoma, in that order. In similarly loose terms, record keeping is least extensive in Provo and Burbank, and most extensive in Tacoma, with Sacramento and Grand Rapids falling between. More complex fee structures of course require more information for administrative purposes, and this information in turn can facilitate management techniques such as cost accounting and use of electronic computers which more accurately determine and predict costs. On the other hand, user charges are clearly not a prerequisite for such data collection, and in some cases expenditure on data collection may be a luxury. In Grand Rapids, where only residential waste is collected by the city, allocational efficiency between residential and commercial collection is not at issue; and in Provo, the smallest of the cities we studied, the benefits of sophisticated management techniques might not outweigh the costs.

These social and political issues have a clear relevance for cities engaged in deciding whether or not to implement user charges for the first time, as do the administrative issues discussed below. Although we had hoped to investigate the implementation process more closely, it proved impossible to do so while at the same time studying examples of cities with each type of user charge. Tacoma has employed user charges for over 50 years. Burbank, Sacramento, and Provo have employed user charges for as long as anyone in the municipal solid waste offices of these cities can recall. Grand Rapids introduced user charges in the early 1970's. The experience of Grand Rapids is discussed in some detail in later sections, as are issues related to implementing changes in fee structures which took place in the other cities.

ADMINISTRATIVE ISSUES

Although formulation of generalizations is difficult on the basis of only one example of each type of user charge, the case study approach nevertheless has illuminated certain differences in the administration of each type of fee structure which warrant further study. Here briefly are the outstanding administrative difficulties encountered with each fee structure in common use, along with some of the solutions devised in the cities we studied.

Location-based fee structures are particularly unpopular with solid waste managers. In Provo the Sanitation Department would like to eliminate the service because at current prices having it is thought to cost the Department more than the added revenues it brings in. Finding a city which has a variable fee based exclusively on pickup location was itself difficult because many cities have abandoned location-based fees in favor of flat fees in recent years. Carryout service remains labor intensive as the technology of collection changes, with the result that the cost of providing carryout service increases relative to other collection services. In Tacoma, where a greater effort is made to see that the price of carryout service covers its cost, we observed an historical increase in relative price of the service and a decrease in percentage of households demanding it. Hence, carryout service is not inherently inefficient in an economic sense, but it may become so if social and political criteria replace economic criteria in deciding whether to offer the service. This seems to be the case in cities where solid waste managers oppose the carryout option.

The principal administrative problem with the metered-bag system is distribution of bags. In both Tacoma and Grand Rapids an initial attempt was made to distribute bags through fire stations. In both cases this solution was inadequate because of staffing problems at fire stations and because people prefer the convenience of buying bags at supermarkets, drug stores, etc. The problem with these is the reluctance of retailers to take responsibility for distribution. Faced with these problems, Tacoma decided not to adopt the bag system. Grand Rapids responded by giving distributors (firemen and shopkeepers) a commission on sales. The cost of commissions mitigates the advantage of eliminating billing costs, but carries the advantage of improving relations with shopkeepers and customers.

Finally, we note two related issues associated with container-based fee structures -- stuffing, and large marginal increments. In both Sacramento and Tacoma about three quarters of all households receive single-can service, and fewer than three percent demand more than two cans. Both cities also require households to pay for a non-zero minimum level of service (one can per week). Households demanding more than the mandatory level of service are therefore offered a price incentive to produce less waste, while those demanding less than the mandatory level (evidently a majority) are offered no such incentive, but rather are in a similar position to households paying a flat fee. Households at the margin -- those whose waste generation fluctuates around one can or two cans per week -- may find the transaction cost of changing service levels so great that they prefer to stuff cans more full. The metered-bag system eliminates the transaction cost, but not the temptation to stuff bags more full. Data in Sacramento and Grand Rapids were inadequate to test hypotheses about stuffing behavior, but evidence from Tacoma indicates that stuffing did occur there until the introduction of a charge for extra bags, which seems to have solved this problem as fully as can be expected short of weighing each separate container of waste. It has been suggested in a similar vein that user charges may lead to increased use of household compactors or sink disposals; we were unable to find data suitable for testing this hypothesis.

SECTION 3

RECOMMENDATIONS

The underlying question of this and many similar studies is whether solid waste managers can affect quantity of waste generated through devices such as user charges. In the next section we shall demonstrate that tests used to estimate price elasticities of waste generation have been deficient for one reason or another; we shall further demonstrate that there have been no adequate tests of the hypothesis that user charges have an effect on littering behavior. The lack of conclusive evidence, both from earlier studies and from the present study, stems largely from the inadequacy of available data in cities employing user charges. Our recommendations, therefore, are twofold. First, there should be further clarification of how user charges are related to efficient management of solid waste systems, so that further research may be directed to areas which hold greatest promise. And second, improved methods of testing economic hypotheses about solid waste generation should be developed which do not rely so heavily on the kinds of data bases which have previously been used.

SECTION 4

THE ECONOMIC EFFICIENCY OF USER FEES: THEORY AND EMPIRICAL RESULTS

Attention directed toward the "efficiency" of alternative organizations for the management of solid waste systems has resulted in a large literature on the subject. For the most part, the literature reflects concern with what we would call the "technical efficiency" of a solid waste management system. That is, it addresses the question of the characteristics of a solid waste management system that minimize the cost to the solid waste management system itself. In this study, we have as our concern a somewhat different concept of efficiency. We are interested in the role of user fees in increasing "economic efficiency." Later in this section, we define more carefully the concept of economic efficiency. Basically, however, it refers to the minimization of costs to society (where society may be defined in terms of the nation, the state, the city, or any other group) while technical efficiency refers to a more narrow concept.

One of the consequences of using economic efficiency as the criterion for judging alternative structures of solid waste management systems is that, a priori, no particular system organization can be called "inefficient." For example, it is often said that backyard systems are "inefficient." The reason for this statement is that, of course, more collector time is required to serve as many households than in a curb/alley system. What the statement neglects to consider, however, is that labor is still required to move the waste from the backyard to the curb. From society's point of view, there remains the question of the least-cost method of getting the waste to the curb.

After defining and discussing the concept of economic efficiency, we shall define alternative user fee structures and evaluate their (theoretical) effects. Then we shall review some of the empirical literature that has attempted to assess, from an economic viewpoint, the effect of user fees on household waste generation. We shall be particularly interested in findings in the following three areas: the price elasticity of waste generation; the income elasticity of waste generation; and the effect of user fees on littering behavior. We find in the literature that, despite some claims to the contrary, there is no evidence of any statistically significant price elasticity with respect to waste generation. Rather, the tests used to estimate the price elasticity are deficient for one reason or another. With respect to income elasticities, there is some statistical support for income elasticities in the range of .3 to .7. Finally, with respect to littering behavior, there is one study that finds a positive correlation with a particular surrogate for litter and the presence of a user fee. However, for the reasons discussed below, the evidence is sufficiently weak to say that there have been no findings and indeed no test, of the hypothesis that the presence of user fees leads to increased littering. Before reviewing the literature, it will be important to define what we mean by economic efficiency and how it might be measured.

ECONOMIC EFFICIENCY

In making decisions, all economic entities from households (or individuals) to national governments perform, if only implicitly, some form of economic analysis. Included in the analysis are the benefits (e.g., revenues in the case of a business) to be derived from a particular action and the costs (e.g., fixed and operating costs) associated with particular actions. This decision process can be used as the basis for the definition of economic efficiency.

No matter what the economic unit, each decision involves the comparison of costs and benefits to be incurred by the unit. In its decision, the decision making unit considers only those benefits accrued and those costs incurred by the unit. For example, an individual deciding whether to litter does not (generally) take into account the costs imposed on others in terms of reduced aesthetics. These costs (or benefits as in the case of innovations) which are incurred by those outside of the organization making the decision are called "external costs," "external benefits," or simply "externalities."

The nature of these externalities leads to confusion when discussing the efficiency of a particular organizational format for a solid waste system. From the viewpoint of, say, the solid waste authority, one particular set of actions may lead to the lowest cost from among a set of possible actions. However, when the decision making organization is expanded to include others (e.g., the residents of the city) a different set of actions may become cost minimizing.

Throughout the report, we shall refer to the economic efficiency of various user charge schemes. By this we mean the difference between the benefits and costs of particular fee structures. Both the costs and the benefits are measured in reference to society. In the case of solid waste systems, society can be the local city or municipality. In general, actions taken by the solid waste authority in one city do not affect citizens in other areas. While not always true (for example, when the disposal decisions by one city affect other cities through, say, effects on river water quality), this can be taken for granted in the cases we will be examining. What should be avoided, however, is the notion that only the costs incurred by the solid waste authority are important or that they are the only costs to be considered. In fact, as we shall see below, schemes that are often thought to be inefficient from the agency's point of view may actually lead to improvements in social welfare.

The meaning of economic efficiency can be easily illustrated. However, we first need to decide upon a method to measure the benefits associated with particular decisions. For a business, the measure of benefits is relatively straightforward. For the municipality engaged in providing a service, however, the measure of net benefits is less clear.

Consumer's Surplus as a Measure of Benefits

Determining the economic benefits of a decision to a private individual or firm is relatively easy. First, the revenues are computed, then the costs. Finally, the costs are subtracted from the revenues to determine net financial profit on which a decision can be based. Because so many activities of governmental units affect people in ways not measured by market transactions, some other method for measuring the net benefit of a course of action must be developed.

The measure that has been developed for use in social cost-benefit analyses is that of "consumer's surplus." Briefly, consumer's surplus is a measure of the individual's willingness-to-pay for a particular service. For example, a particular individual may be willing to pay $6.00 per month for carryout service. The net consumer's surplus, or what the consumer would be willing to pay less what he actually pays, is the measure traditionally used in cost-benefit analyses. Continuing the example, if the service were provided at no additional charge to the resident, then the consumer's surplus would be $6.00 (i.e., $6 - $0). This measure of willingness-to-pay can be directly related to other concepts in economics — concepts which can be measured more easily than willingness-to-pay.

To begin, let us examine the economic benefit that a typical consumer derives when he purchases, say, carryout service. Suppose that the price of carryout service is $6 per month. We may infer that each purchaser of carryout service is willing to pay at least $6 to have it rather than to go without it. Actual expenditures on such service thus represent a lower bound on the sum of purchaser's willingness-to-pay to have the service. We can infer from their behavior that they are willing to pay at least this much. In fact, of course, they may be willing to pay much more.

To be able to infer actual willingness-to-pay from observed behavior, we clearly require more information. Exactly the needed information is provided by the fact that the marginal buyer (i.e., the buyer who would not buy if the price were any higher) is willing to pay exactly the price he pays and no more. By using this fact, we can find a differential equation representing market behavior which, in principle, can be used to measure willingness-to-pay exactly.

Letting x denote the total number choosing carryout service per unit of time, and letting $p(x)$ represent the price corresponding to x, we note that marginal willingness-to-pay when (say) X_0 units are purchased is:

$$p\ (X_0) = \frac{dW}{dX} \tag{1}$$

where W is willingness-to-pay. Total willingness-to-pay may then be found by solving this differential equation for W, which yields

$$\int_0^{X_0} p\ (x)\ dx = W \tag{2}$$

Equation (2) provides the fundamental relationship that is used to translate the willingness-to-pay principle of benefits measurement into practice. What equation (2) says is that, if we can find the market relationship between price, "p," and number choosing the service per unit of time, "x," (this is the relationship we have denoted by p(x)) we will have exactly the relationship that we need to measure willingness-to-pay.

This relationship between p and x is nothing other than the "market demand function," which relates price and quantity demanded for goods and services. Of course, variables other than price and quantity are important in this relationship. For example, we know that income, household age, and many other factors influence demand. These other factors are taken into account in the analysis, as will become clear in later chapters in which we use equation (2) to make actual benefits estimates. For ease of exposition and notation here, however, we shall retain our convention of expressing explicitly only price and quantity.

Once we have the demand function (we shall illustrate in subsequent sections how it is estimated), we obtain an estimate of the sum of individuals' willingness-to-pay to have an activity with an output level of (say) X_0 per year by integrating under the demand function up to X_0, as shown in equation (2) above.

This procedure for estimating individuals' willingness-to-pay may be easily illustrated. In Figure 1, we have drawn a demand curve. At quantity X_0, total willingness-to-pay is given by the area under the demand curve up to X_0, which is the shaded area in Figure 1.

Frequently in cost-benefit analysis, willingness-to-pay is measured net of any charges levied upon customers. When this is done, the result is called "net willingness-to-pay," or more frequently, "consumers' surplus." The "consumers' surplus" measure represents what customers would be willing to pay over and above what they do pay. This concept is illustrated in Figure 2, where it is assumed that a price of P_0 is charged for each of the X_0 units purchased. The shaded area in this figure represents consumers' surplus (or net willingness-to-pay). The total

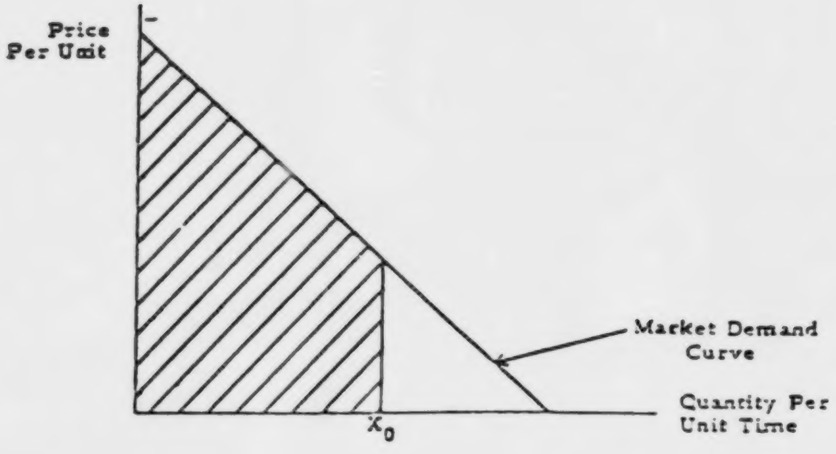
Price
Per Unit
Market Demand
Curve
Quantity Per
Unit Time
X_0

Figure 1. Illustration of the calculation of total willingness-to-pay.

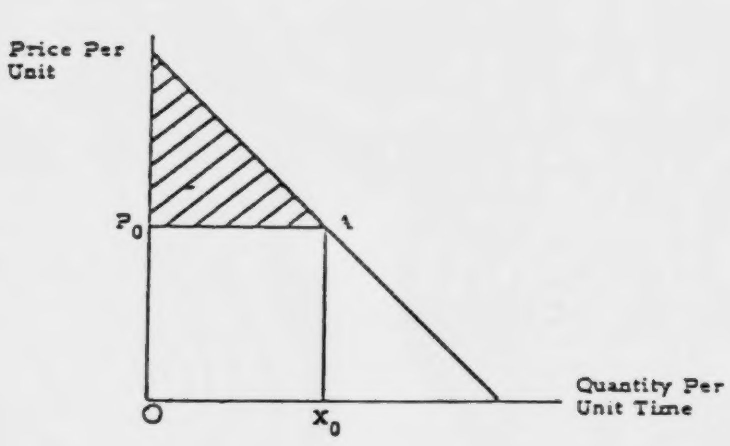
Price Per
Unit
P_0
O
X_0
Quantity Per
Unit Time

Figure 2. Illustration of the calculation of consumers surplus.

user-expenditures that have been netted out of willingness-to-pay are given by the rectangle OP_0AX_0. (Compare Figure 2 with Figure 1.)

A Graphical Depiction of Economic Efficiency

The measure of consumers' surplus described above is, of course, only one half of the information required to assess system efficiency. The other part is the cost of implementing the system. Still, it is possible to depict graphically the assessment of economic efficiency for a particular service.

Consider, for example, the question of carryout service. If refuse collection services are provided by the city, it has three basic alternatives: provide the service to all residents; provide the service to no residents; or charge a fee for the service and let the individual resident choose. The comparative benefits can be assessed using the information presented in Figure 3.

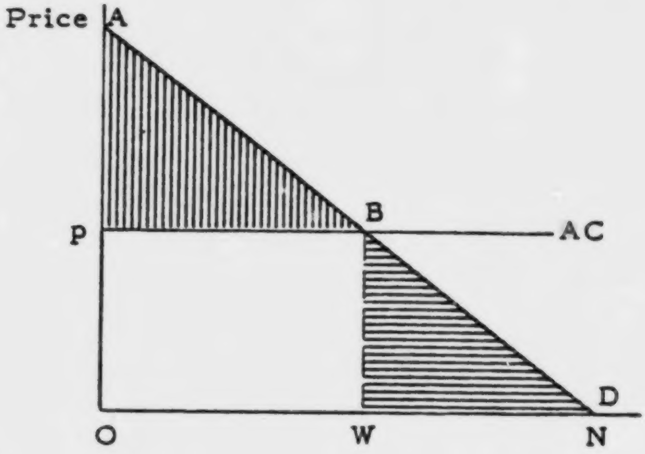

Figure 3. Evaluating economic efficiency.

In Figure 3, the demand for carryout service is drawn as a linear function of price only for simplicity. It is assumed that at zero price, all residents will demand the service. While this may not be true (if, for example, some residents feel there are additional costs to having collectors enter their yards) nothing in the analysis is altered by this assumption. Suppose that, if the service is offered for a fee, the fee (p) will be set to equal the average cost of providing the service. (Average costs are drawn as constant in Figure 3, implying that average costs equal marginal costs. We have excluded from the figure any administrative costs which might be associated with the use of a fee.)

Consider now the net social benefits associated with the three alternatives outlined above. The first alternative, providing the service to everyone without an explicit charge, is equivalent to charging a zero price. Therefore, the demand is 100%. The total willingness-to-pay (i.e., the area under the demand curve) is equal to the area OAD. The total cost of providing the service is N x AC where N is the number of residents. (There are no administrative costs since the service is provided to everyone and no monitoring is required.) Therefore, the net benefits to society is equal to the total benefits less net costs and depends on the relative size of the two shaded areas in Figure 3.

Now consider the net social benefits of not providing the service at all. In this case the net benefits are zero -- no costs and no benefits.

Finally consider charging a price p (assumed to be equal to average cost). The percentage choosing the service will be W. The total benefits are OABW. The total costs are AC x W. The net social benefits are the vertically shaded area pAB. Note that the net benefits associated with this arrangement are greater than those associated with providing the service to everyone by the amount WBD (the horizontally shaded area) neglecting the administrative costs.

Similarly, the net benefits associated with the charge system are greater than providing no service (again neglecting administrative costs) by the amount pAB. The question of the best choice depends then on the level of administrative costs. If they are less than pAB, a charge system is, on net, beneficial when compared to providing no service. If they are less than the area B(AC)D, then the charge system has greater net benefits than the free provision. Of course, the level of the administrative cost and the relative magnitude of the shaded area are empirical questions.

Suppose, however, that in the process of trying to evaluate the net social benefits associated with a particular fee structure, that the analyst is missing some of the crucial information; e.g., the actual demand curve for the service. Is there some necessary condition that must hold for a user fee to improve economic efficiency (not equity)? The answer is yes. Basically, it must be true that the demand curve has a negative (i.e., non-zero) slope. Consider what happens if the slope (or elasticity) is zero in the relevant range. If the elasticity is zero, the waste presented for collection remains the same and, therefore, total costs remain the same. All that happens is that there is a transfer payment from residents to the solid waste system, and under traditional cost-benefit analysis such a transfer has no effect on benefits.

A CLASSIFICATION OF FEE STRUCTURES

As discussed above, the approach followed in this study has been a case study approach of five cities each of which has a different type of fee structure. By "different" we mean merely that the resident in each of these cities is faced with a different set of choices concerning the disposal of the solid waste generated within the household. Before discussing the findings in each of the five cities, however, it is useful first to discuss the classification systems used to develop the five different fee structures. Once this has been done, we can analyze what the qualitative effect of a fee increase would be.

The Categories of Fees

The nature of the fee systems used by communities that employ user fees for the collection of residential solid waste vary greatly. However, within that variation, there is one characteristic which is (a) easy to identify, (b) useful in the development of hypotheses concerning behavior, and (c) restricted in relevant possibilities. This characteristic is, therefore, a sound one to use for the classification of user fee systems for the purposes of selecting the case study cities. This characteristic is the set of decision choices the resident has for the disposal of solid waste. Although there may be others, we have selected five different possibilities as including (hopefully) most of the fee structures currently used. Below we identify and define each type.

Uniform Fee Structure--

The first, simplest, and by far the most widely used fee system is the uniform or flat fee structure. In this system, the resident (assuming service is mandatory) has no choice over his disposal options. (By choice, we mean an alternative offered by the provider of the service. Certainly, every resident can choose to dispose of waste illegally.) The goal of this type of fee structure is basically one of revenue raising. In other words, the flat fee service is an alternative to general tax revenues for supporting the solid waste system. Burbank, California, is an example of a city which uses a flat fee structure.

Container-Based Structures--

A more complex system is one in which the resident has the option to choose the number of containers (i.e., the capacity) for waste for pickup. While it is not necessary to assume that the resident must remain within that constraint once and for all, it is assumed that there are some transaction costs associated with frequent changes from one number of containers to another that are sufficiently large to discourage such changes. Sacramento, California, is an example of a city which uses a container-based fee structure.

Service-Based Structures--

A third type of fee structure is one in which the resident can choose alternative levels of service. Service levels can be defined in terms of the point of collection (curbside or backyard) or frequency of collection (e.g., weekly or semi-weekly). Most cities that have a service-based system provide a choice in terms of location. In this system, the number of containers that can be presented is specified (although it may be unlimited). Provo, Utah, is an example of a city which uses a service-based fee structure.

Metered-Bag Systems--

Metered-bag systems are those systems where the resident presents all waste to be collected in a specially-marked bag. This system is quite similar to the container-based system discussed earlier. The difference, an important one, is that the resident can alter, at no transaction cost, the number of containers presented each time. While this system is not a true quantity-based system, where the resident pays for collection according to the weight or volume of the waste presented, it is a step closer to that ideal because of the freedom offered at each collection period. Grand Rapids, Michigan, is an example of a city which uses a metered-bag system.

Combination Systems--

Finally, some municipalities employ fee structures that are combinations of two or more of the other systems. For example, in Tacoma, Washington, the resident chooses both the number of containers and the level of service (in terms of pickup location). This type of system may be expected to be more expensive yet more flexible than a system offering only one choice. Tacoma, Washington, is an example of a city which uses a container- and service-based fee structure.

Analyzing the Effect of Different Fee Structures

In theory, one could qualitatively analyze the impact upon resident behavior from the change in the level of the fee for any type of fee structure by first developing a utility maximization model with each of the fee features. Then, comparative statics could be used to determine the direction of change in the amount of waste generated. Such an approach was used, for example, by Kenneth Wertz (1976) [2] when analyzing the effect of price and service level upon waste generation behavior. The problem with such an approach is that, of necessity, most of the fee systems that exist include in their rate structures such large discontinuities (e.g., the number of containers) that applying such methods may not be particularly fruitful when examining actual systems. The results of the Wertz analysis are helpful, however, in that they provide a check on a more simple approach to the qualitative determination of the effects of a fee change.

Consider, for example, an "ideal" fee structure where the resident pays by the pound (or cubic foot, or both) for the amount of waste disposed. Further, suppose that he is allowed to choose the point of collection (for a fee). A system of demand equations that might be expected to model such a decision process adequately would be like the two equations:

$$q = f(\overset{-}{p_w}, \overset{+}{y}, \overset{+}{s}) \tag{3}$$

$$s = g(\overset{-}{p_s}, \overset{+}{y}) \tag{4}$$

where q represents the quantity of waste disposed, p_v the price per unit of waste, y is disposable income (after payment of any flat fee for disposal), s is a measure of service level (e.g., the number of feet from the curb), and p_s is the unit price of the service level. Signs above each of the independent variables in both equations indicate the effects we would expect changes to have. For example, following elementary theory we would expect that an increase in the price of either quantity or service would decrease the demand for the respective good. Similarly for income. In equation (2), we show that the effect of an increase in service level leads to an increase in the amount of waste generated. This is consistent with the findings of Wertz. Intuitively, its justification is quite straightforward. The disposal of residential solid waste requires the labor of two different units: the collector and the household. Use of household labor is costly just as is the use of the collectors' labor. Increasing the service level while holding all other variables constant means that the cost to the household of presenting an additional unit of waste has fallen. We would therefore expect to observe an increase in the amount of waste presented.

We can now use equations (3) and (4) to determine the effect of a change in the price of either quantity or service level. The effect of a change in the price of quantity is known directly from the demand curve. The effect of a change in the price of service level upon the amount of waste generated depends on the indirect effect of the service price on the level of service. Thus,

$$\frac{\partial q}{\partial p_s} = \frac{\partial q}{\partial s} \cdot \frac{\partial s}{\partial p_s} < 0 \tag{5}$$

The effect of an increase in either price therefore is expected to be a decrease in the amount of waste presented for collection. These results were for the ideal system. We now evaluate the five types of fee structures described above.

Uniform Fee--

In the case of the uniform fee, the only equation is:

$$q = f(\overset{+}{y}) \tag{6}$$

Note that the only variable influencing the amount of waste presented for collection is the disposable income. This fact has an important implication that has, on occasion, been overlooked in previous analyses. Suppose we define,

$$y = m - p \tag{7}$$

where m is household income before the fee and p is the flat fee. It follows immediately that:

$$\frac{\partial y}{\partial p} = -1 \text{ and } \frac{\partial y}{\partial m} = 1$$

Combining (6) and (7) and substituting these results, we have:

$$q = f(y) = f(m - p)$$

$$\frac{\partial q}{\partial p} = \frac{\partial q}{\partial y} \cdot \frac{\partial y}{\partial p}$$

$$= -\frac{\partial q}{\partial y}$$

$$= -\frac{\partial q}{\partial y} \cdot \frac{\partial y}{\partial m}$$

$$\frac{\partial q}{\partial p} = -\frac{\partial q}{\partial m} \tag{8}$$

That is, the effect of an increase in the flat fee is equivalent to an equal decrease in income. The income elasticity of quantity of waste generated is:

$$\eta_m = \frac{\partial q}{\partial m} \cdot \frac{m}{q} \text{ or } \frac{\partial q}{\partial m} = \eta_m \frac{q}{m}$$

Multiplying both sides of (8) by p/q and substituting this result, we have:

$$\frac{\partial q}{\partial p} \cdot \frac{p}{q} = -\frac{\partial q}{\partial m} \cdot \frac{p}{q}$$

$$\frac{\partial q/q}{\partial p/p} = -\eta_m \frac{q}{m} \cdot \frac{p}{q}$$

$$\eta_p = -\eta_m \frac{p}{m} \qquad (9)$$

As indicated in equation (9), this is the elasticity of quantity of waste generated with respect to the flat fee. This means that if the income elasticity of waste generation is on the order of .30, then the elasticity with respect to a change in the level of the flat fee is insignificant.

Container-Based Fees--

The container-based system differs from the ideal because the resident does not face an explicit charge each collection. Rather, he faces what is essentially a capacity constraint. Therefore, his choice can be modeled as:

$$q = f\,(\overset{+}{c}, \overset{+}{y}) \qquad (10)$$

$$c = g\,(\overset{-}{p_c}, \overset{+}{y}) \qquad (11)$$

Again, the signs above the independent variables represent our assumptions about the effects of changes in these variables on the amount of waste generated. In these equations, C represents the number of cans selected. Ignoring the discontinuity of the number of cans, we can analyze the effect of an increase in the price per can on the amount of waste generated. It is:

$$\frac{\partial q}{\partial p_c} = \frac{\partial q}{\partial c} \cdot \frac{\partial c}{\partial p_c} < 0 \qquad (12)$$

The product of the two terms in (12) is negative by virtue of the effect of price on the number of containers selected. However, if the first factor is less than one, it can moderate any inhibiting effect of the price change. The factor $\partial q/\partial c$ measures the density change resulting from a change in price. That is, if $\partial q/\partial c$ is less than one, part of the effect of the change in price is to have residents packing each container slightly more full. This would be a perfectly rational thing to do since, as the price of an additional can increases, the cost of the residents own labor in the preparation of his waste for collection falls.

This suggests that one of the weaknesses of the container-based system is that it provides a means for the resident to avoid the full effect of the price increase. Of course, the quantitative importance of this effect is an empirical question.

Service-Based Fee—

The model for a service-based fee would be

$$q = f(\overset{+}{s}, \overset{+}{y}) \tag{13}$$

$$s = g(\overset{-}{p_s}, \overset{+}{y}) \tag{14}$$

Here we are interested not so much in the effect of changes in the level of the fee on the choice of service level by the resident, which we know must be negative, but the effect on the quantities of waste generated. But this is just,

$$\frac{\partial q}{\partial p_s} = \frac{\partial q}{\partial s} \cdot \frac{\partial s}{\partial p_s} < 0 \tag{15}$$

Therefore, we see that the effect is dependent upon two quantities -- the effect of price on service and the effect of service on quantity.

The Metered-Bag System--

The bag system differs from the capacity-based system in two important respects. First, the resident is free to put out a different number of bags (including zero) each collection period. The second is the fact that each bag used includes the cost of the bag. With a container, the container was not "consumed" when filled (although it must eventually be replaced). With the bag it is. Therefore, the system of demand equations for this system is

$$q = f(\overset{-}{p_B}, \overset{+}{B}, \overset{+}{y}) \tag{16}$$

$$B = g(\overset{-}{p_B}, \overset{+}{y}) \qquad (17)$$

where p_B is the price of a bag. Note that the price of bags affects the demand for two separate goods, the collection of waste and the number of bags. Therefore, we would expect the effect of a price change to be somewhat more complicated. In fact, it is,

$$\frac{\partial q}{\partial p_B} = \frac{\partial q}{\partial p_B} + \frac{\partial q}{\partial B} \cdot \frac{\partial B}{\partial p_B} < 0 \qquad (18)$$

Combination Systems--

The combination systems combine the effects of two or more of the types of fee structures. Assuming that the combination is for the number of containers and the location for pickup, the model for analyzing the effect of fee changes might be

$$q = f(\overset{+}{c}, \overset{+}{s}, \overset{+}{y}) \qquad (19)$$

$$c = g(\overset{-}{p_c}, \overset{+}{y}, \overset{+}{s}) \qquad (20)$$

$$s = h(\overset{-}{p_s}, \overset{+}{y}, \overset{+}{c}) \qquad (21)$$

Measuring the effect of a change in the price per container of waste collected is now complicated by the fact that the container fee will affect both the number of containers selected and the level of service chosen. The effect of a change in the fee for a container is

$$\frac{\partial q}{\partial p_c} = \frac{\partial q}{\partial c} \cdot \frac{\partial c}{\partial p_c} + \frac{\partial q}{\partial s} \cdot \frac{\partial s}{\partial c} \cdot \frac{\partial c}{\partial p_c} < 0 \qquad (22)$$

the effect of the change in the fee for level of service is

$$\frac{\partial q}{\partial p_s} = \frac{\partial q}{\partial s} \cdot \frac{\partial s}{\partial p_s} + \frac{\partial q}{\partial c} \cdot \frac{\partial c}{\partial s} \cdot \frac{\partial s}{\partial p_s} < 0 \qquad (23)$$

We see that in both cases the impact of an increase in either fee is to reduce the amount of waste presented for collection.

We now review some studies of the effect of user charges on residential solid waste concentrating on those which are empirically oriented. The purpose of this is to: (1) provide a background for comparison of our results, and (2) assess the previous findings which have been used in discussions of policy related questions.

REVIEW OF THE LITERATURE

While there have been innumerable studies of the cost of providing solid waste collection services (along with many prescriptions for decreasing agency, though not necessarily social, costs with particular technologies), there have been relatively few studies that empirically address the effects of pricing on residential solid waste behavior. Without such information, however, analyses of the "optimal" type of fee structure are impossible to perform in terms of cost-benefit analysis. The purpose of the following is to provide a brief, and admittedly selective review of the empirical literature that has developed in this area. The reason for focusing on the following studies is that they form the basis for much of the current discussion regarding solid waste pricing, and because they provide numerical estimates of elasticities and other economic data that have come to be relied upon in policy-making discussions. It is important that they be assessed critically in order that due faith be placed in the results.

Wertz

The Wertz (1976) [3] article is primarily concerned with the development of qualitative implications for the effects of changes in service fees or quantity fees. However, throughout the paper are several brief examples which provide some support for the theoretical propositions developed. The ones which we are primarily interested in are those relating to income elasticities, price effects, and service level effects.

With respect to income effects, Wertz used data from 10 suburbs of Detroit which had similar financing and collection policies. Using a linear functional form for the demand curve, Wertz found implied income elasticities of .279 and .272 (depending on the actual sample used). In a rather odd conclusion, Wertz states "The foregoing mixture of theory and observation suggests the expected: residential refuse quantities should decline as t (price) increases."

The "foregoing mixture" of theory appears to be the derivation of the usual classification of effects into substitution and income effects. This is perfectly straightforward following usual demand theory. What is not clear is how the observations about income elasticities from cities employing no incremental user charge can support expectations about price elasticities.

Following this conclusion, Wertz examines some additional evidence bearing on the price effect. He cites the fact that per capita generation in San Francisco, which employs an incremental user fee, was substantially less than "for all urban areas where general financing prevails." As Wertz notes, there are too many variables to place too much belief in the numerical accuracy of the implied price elasticity of .15. In addition to the lack of data, moreover, the comparison was between two different years made comparable by applying "an average growth rate." Also, the growth rate was applied to a figure which was composed of measured tons and estimated (from volume) tons.

The estimates Wertz provides on income elasticities appear to be consistent with the findings of others and are based on statistically sound methods. However, the empirical evidence of a non-zero price elasticity is not soundly based.

Tolley, Hastings, and Rudzitis

In an updated version of an earlier study, Tolley, et al. [4], provides estimates of income elasticities based on cross-sectional data from several wards in Chicago. Because waste collection services are financed out of general revenues in Chicago, no estimates of price elasticities were possible.

The findings of Tolley, et al., were consistent with the earlier work. Namely, the estimated income elasticity in Chicago appears to be .3 and .7, depending on the season.

Again, these findings are consistent with those of others: there is an income elasticity which is positive but less than one.

McFarland

One of the most oft-cited studies concerning the existence of a significant price elasticity is the study by the University of California on solid waste practices in that state [5]. Chapter IV, which formed the economic basis of the report was authored by McFarland and has come to be known by that name. We will therefore continue to use it.

The approach McFarland used to estimate the price elasticity was to apply ordinary least squares to the following equation:

$$Q_d = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3}$$

where Q_d is the annual per capita quantity of waste generated, X_1 was average revenue, X_2 was per capita income, and X_3 was population density. The results of the regression were:

$$\ln Q_d = 6.9 - \underset{(3.2)}{.455}\ln X_1 + \underset{(.36)}{.178}\ln X_2 - \underset{(1.5)}{.212}\ln X_3$$

where t-statistics are noted in parentheses. McFarland used this result to state: "This indicates that people will definitely respond to price incentives or disincentives in their use of the service." There are, however, several problems with these results -- problems which essentially vitiate the conclusions.

First, the price proxy used was average revenue. Unfortunately, McFarland did not specify the actual 13 cities used in the analysis. However, since only two out of the 58 in the entire study appear to employ an incremental user fee, the majority had to be flat-fee cities. In that case, there is no price elasticity. A second problem is that many flat-fee cities impose quantity limits. This means that service levels are not held constant.

Finally, there is undoubtedly a good deal of simultaneity. Most municipal systems are designed so that the flat fee is, at least somewhat, related to system costs. But system costs are related to the level of waste collection. Therefore, by not including a second equation in the model and using simultaneous methods, the results do not have the usual desirable properties.

These problems may also have led to the finding of an income elasticity not significantly different from zero, a finding which conflicts with other studies.

McFarland goes on in the analysis to discuss the effect of incremental fees on litter -- the primary externality to be expected from the imposition of a user fee. To do this, she classifies cities as internalizing or externalizing depending upon their mode of financing and quantity limitations. Externalizing cities are those cities not "providing unlimited or generous service at zero marginal costs." She then found a significant difference in the costs associated with the solid waste management system between the two types of cities. She attributed this difference to the extra costs of litter cleanup in the externalizing cities.

The results of this analysis have been criticized elsewhere (see, e.g., Goddard, Hudson) [6], [7]. However, an important point that we have not seen mentioned is that flat-fee cities imposing quantity limits (while perhaps by definition incremental fee cities, i.e., with an infinite incremental fee) are not what is generally meant by incremental fee cities.

The empirical results of McFarland, therefore, do not appear to be sufficient evidence of the existence of non-zero price elasticities either directly from demand equations or indirectly through litter effects.

Stevens

In an unpublished research paper, Barbara Stevens has presented some results, both theoretical and empirical, concerning service level pricing [8]. In the theoretical analysis she extends the results of Wertz by explicitly including frequency of collection and location of pickup simultaneously. She concludes the theoretical section with:

> All mandatory collection systems, whether the fee is explicit or implicit, cause the consumer to generate less wastes when prices are increased (provided that either the price elasticity of demand for service or that the relation between refuse generation and income is small) and cause the consumer to generate more wastes in response to a costless increase in service level. Only the service level fee pricing scheme has the joint advantage of encouraging consumers to value goods implicitly according to the disposal cost of their refuse component and of implementability.

It is important to note her qualifier "mandatory." She goes on to assert:

> When a pricing scheme does not require mandatory participation of households, none of the above conclusions, with respect to any of the pricing models, can be stated with any confidence. In any such non mandatory arrangement, increases in the price of refuse collection services can lead to a decrease in the proportion of households selecting organized collection services. The households opting out of the system may choose to self haul to legal disposal site (sic), to dump in illegal locations, to burn refuse, etc. Any or all of these alternative disposal technologies may result in a perceived increase in disposable income and a consequent increase in refuse generation. In addition, some of these alternate disposal technologies may result in increased total costs of collection and disposal of refuse to be borne by the society as a whole.

The reason for such a counterproductive effect, at least in terms of economic theory, is unclear. For if the resident could make use of the alternative facilities at lower cost than at the new user fees, the same alternatives were available at the lower fee level. That is, let $p(Q)$ be the price of disposing of an amount Q through "conventional" means. Let $L(Q)$ be the "price" of some alternative form of disposal (e.g., littering). Then the resident will choose quantities Q_c, Q_L to be disposed of conventionally and littered so that

$$TC = p(Q)Q_c + L(Q)Q_L$$

is the total cost of waste disposed. Total waste generated is just $Q_c + Q_L$. Now suppose there is a price increase in conventional disposal. Regardless of the functional forms of the price functions $p(Q)$ and $L(Q)$, the total cost cannot fall. (It is true, however, that there will be more waste disposal through illegal means, and, therefore, social costs may increase.

The difference between mandatory and non-mandatory systems is that, under the latter, the resident has more substitution possibilities available. Thus, in such systems, we would expect the inhibiting effect of any price increase to be more moderate than with a mandatory system.

With respect to the empirical portion of the paper, Stevens provides a useful test of the efficiency of service-based fee systems. Stevens estimates three demand curves: one for waste presented for collection; demand for service frequency; and demand for service location. Using the latter two, we can estimate consumers' surplus and, hopefully, say something about the effect on economic efficiency of service-based plans.

For example, the demand curve for location of pickup is

$$BY = 271 + .00297Y - 142.9QH + .381FRE - 3.279P_{BY} - .0282DEN \quad (24)$$

where BY = percent of households selecting backyard service
Y = mean annual family income
QH = annual tons of refuse per household
FRE = percent selecting higher frequency of service
P = price (per month) for carryout service
DEN = persons per square mile

Significant explanatory variables were income and price.

Substituting the mean values for each of the variables except price into (24), we get

$$BY = 34 - 3.279P_{BY} \quad (25)$$

Equation (25) can be used to estimate consumers' surplus. First note that (25) is linear and therefore consumers' surplus is just the triangle bounded by the demand curve, the price, and the price such that BY is just zero. That is,

$$CS = BY \times (p_{max} - P_{BY}) \times .5 \quad (26)$$

where p_{max} is the price such that BY is just zero. From (25) p_{max} = \$10.36. Using mean values for BY and p , we find

$$CS = (.01 \times 28) \times (10.36 - 1.88) \times .5 = \$1.18/\text{month} = \$14.14/\text{year}$$ [2]

Note that BY is measured in percentage points (of households), so it is necessary to multiply $\overline{BY}$ by .01 to compute consumers' surplus per household.

To determine whether the offering of such a service leads to an increase in efficiency, we need to compare this benefit to the administrative costs of providing the optional service (we assume that the price includes the additional collection costs). While there are no data, we can infer likely effects. Stevens' sample generated 1.71 tons per household annually. Assuming average collection and disposal costs of \$30 (see Savas) [9], total annual costs per household would be \$51. The benefits of \$14.14 annually per household represent 28 percent of this. Edwards and Stevens [10] found administrative costs to be between 3% and 18% of collection and disposal costs. Thus, it appears that providing the optional service increases economic welfare.

Because of the assumptions necessary to estimate consumers' surplus in this case, we would not want to say that the Stevens' results can be used to infer that service-based plans increase economic efficiency. We would argue, however, that they are highly suggestive.

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[2] An alternative method which produces the same result is to integrate the function given by equation (25), thus:

$$CS = .01 \int_{1.88}^{10.36} (34 - 3.279P_{BY})\, dP_{BY}$$

$$= .01 \left[34P_{BY} - 1.64P^2_{BY} \right]_{1.88}^{10.36}$$

$$= \$1.18 \text{ per month} = \$14.14 \text{ per year.}$$

CONCLUSIONS

Based on theory and previous studies relatively little can be said about the magnitudes of price and income elasticities. There exists no statistically valid evidence of a quantity effect. Stevens' result suggests that price is important to the resident in selecting service levels.

In the next five sections, we present our analyses of the effects of five different types of fee structures. As with the studies reviewed here, the results (or lack of results) depends on the amount and quality of data available.

SECTION 5

BURBANK, CALIFORNIA

The City of Burbank, California employs a flat-fee system for residential solid waste collection. Service from the City is mandatory for all residents in single family dwellings (60% of all housing units) and is available to residents in multifamily housing. Service is offered once-weekly and there is no limit to the amount of waste that may be presented for collection provided only that it is properly packaged. (See the Figure 5 for the relevant regulations.) These two factors mean that City residents have no incentive either to reduce the amount of waste generated or to engage in illegal disposal methods in response to a fee increase.

As we show below, the income elasticity estimated for Burbank, given the assumptions and model specification discussed below, is consistent with previous findings. Recall that with a flat fee there is no non-zero price which the resident faces but rather a one-time charge that operates through an income effect. Therefore, there is no price elasticity to be estimated.

In this section, the features of the solid waste management system for Burbank are first described and the data that we were able to collect are discussed. We then describe the theoretical model used in conducting the empirical analysis followed by the empirical results from the Burbank study. Finally, the conclusions that may be drawn from the Burbank case study are presented.

THE BURBANK SOLID WASTE SYSTEM

Collection of residential solid waste in Burbank is accomplished primarily with side-loading trucks using one-man crews. Three two-man crews are used in areas where, for safety reasons, the one-man crews would be undesirable. Waste is hauled to and disposed of at a sanitary landfill located on city property in the Verdugo Mountains. (The Verdugo Mountains form the Eastern boundary of the city.)

Billing for the city service is done through the city-owned Public Service Division which operates the electric utility for the city. The refuse bills are sent out along with the electricity bills to each customer. The equipment for the refuse department is leased from the Equipment Division, which, like the Sanitation Division, is part of the Public Works Department.

Collection of Residential Solid Waste in Burbank

The collection of residential solid waste in the City of Burbank is accomplished by fourteen side-loading refuse trucks using one-man crews and three rear-loading trucks using two-man crews. The rear loaders are used on routes where, because of narrow streets, the truck would be required to back out. The switch to one-man crews was made in 1971 after a study of the existing collection practices.

In addition to residential collection, the city provides service to commercial establishments and multifamily housing if requested by the customer. City offices and local schools are also served by the Sanitation Division. As of February 3, 1978, the city was serving 1,188 commercial accounts.

There are approximately 31,000 residential customers, of whom 18,000 are in single-family dwellings, and the remaining 13,000 in multifamily housing. In 1970, there were a reported 35,000 customers although this figure was not broken down by type of housing.

Service is provided to each residential customer once per week. The particular day of pickup is determined by the customer's location in the city. The map shown in Figure 4 provides the schedule. The regulations for refuse service are shown in Figure 5. If a particular customer is in violation of these regulations, he is notified by the attachment of a red tag to his container.

Collection in Burbank is based on the curb/alley type of system. With the one-man crews, the collection system in Burbank has many of the features normally associated with a technically efficient refuse collection system. However, lack of data prevents us from estimating cost functions for either collection or disposal.

The refuse collectors in Burbank are not unionized. They work on a group incentive basis. That is, when each crew is finished with its route, it is dispatched to help crews that have not finished their routes. In this way, all personnel leave at the same time. The number of personnel for residential solid waste collection totals 22.5 and has remained at this level since 1971. This figure is composed of:

One-man operators	14
Two-man operators	6
Foreman	1
Superintendent	1
Clerk	.5

Disposal of Residential Solid Waste in Burbank

The residential solid waste collected in Burbank is hauled to a sanitary landfill located on city property in the Verdugo Mountains. The approximate location of the current landfill site is shown on the map in

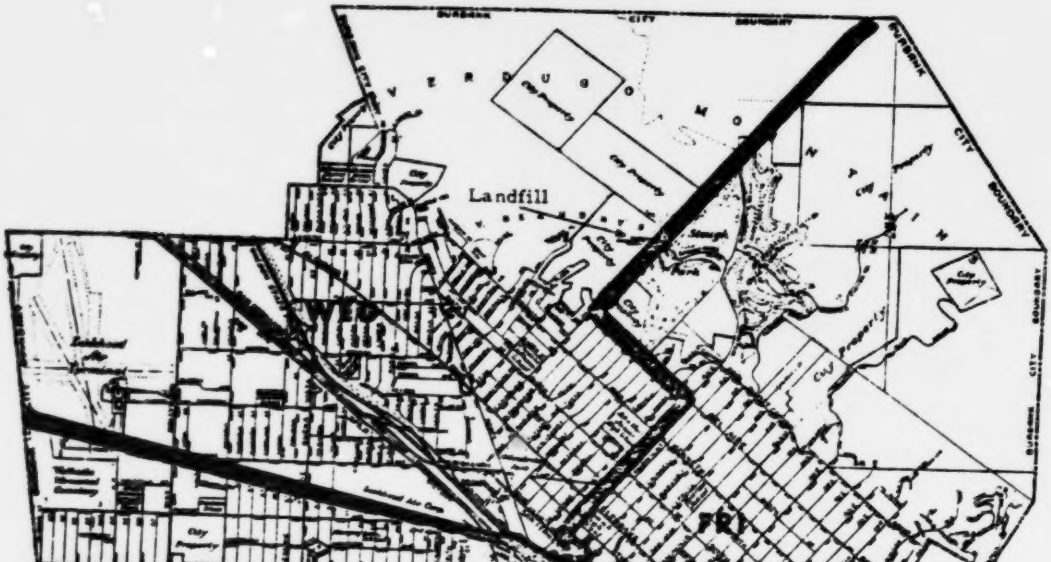
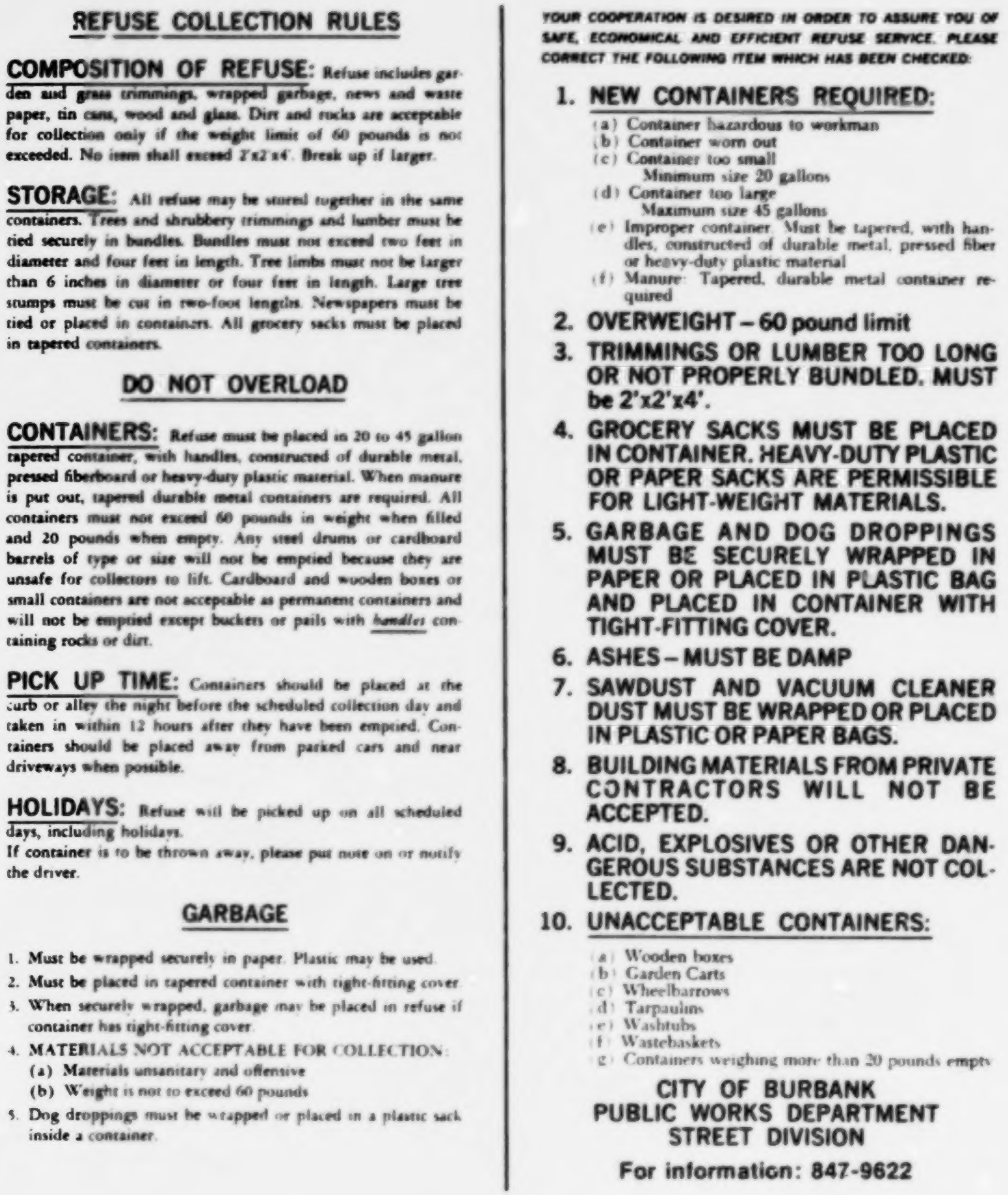

BURBANK CITY BOUNDARY
VERDUGO MOUNTAIN
City property
Landfill
WED
TUE
FRI
THUR
MON

Figure 4. Burbank residential refuse routes.



REFUSE COLLECTION RULES

COMPOSITION OF REFUSE: Refuse includes garden and grass trimmings, wrapped garbage, news and waste paper, tin cans, wood and glass. Dirt and rocks are acceptable for collection only if the weight limit of 60 pounds is not exceeded. No item shall exceed 2'x2'x4'. Break up if larger.

STORAGE: All refuse may be stored together in the same containers. Trees and shrubbery trimmings and lumber must be tied securely in bundles. Bundles must not exceed two feet in diameter and four feet in length. Tree limbs must not be larger than 6 inches in diameter or four feet in length. Large tree stumps must be cut in two-foot lengths. Newspapers must be tied or placed in containers. All grocery sacks must be placed in tapered containers.

DO NOT OVERLOAD

CONTAINERS: Refuse must be placed in 20 to 45 gallon tapered container, with handles, constructed of durable metal, pressed fiberboard or heavy-duty plastic material. When manure is put out, tapered durable metal containers are required. All containers must not exceed 60 pounds in weight when filled and 20 pounds when empty. Any steel drums or cardboard barrels of type or size will not be emptied because they are unsafe for collectors to lift. Cardboard and wooden boxes or small containers are not acceptable as permanent containers and will not be emptied except buckets or pails with *handles* containing rocks or dirt.

PICK UP TIME: Containers should be placed at the curb or alley the night before the scheduled collection day and taken in within 12 hours after they have been emptied. Containers should be placed away from parked cars and near driveways when possible.

HOLIDAYS: Refuse will be picked up on all scheduled days, including holidays.
If container is to be thrown away, please put note on or notify the driver.

GARBAGE

1. Must be wrapped securely in paper. Plastic may be used.
2. Must be placed in tapered container with tight-fitting cover.
3. When securely wrapped, garbage may be placed in refuse if container has tight-fitting cover.
4. MATERIALS NOT ACCEPTABLE FOR COLLECTION:
   (a) Materials unsanitary and offensive
   (b) Weight is not to exceed 60 pounds
5. Dog droppings must be wrapped or placed in a plastic sack inside a container.

YOUR COOPERATION IS DESIRED IN ORDER TO ASSURE YOU OF SAFE, ECONOMICAL AND EFFICIENT REFUSE SERVICE. PLEASE CORRECT THE FOLLOWING ITEM WHICH HAS BEEN CHECKED:

1. **NEW CONTAINERS REQUIRED:**
   (a) Container hazardous to workman
   (b) Container worn out
   (c) Container too small
   Minimum size 20 gallons
   (d) Container too large
   Maximum size 45 gallons
   (e) Improper container. Must be tapered, with handles, constructed of durable metal, pressed fiber or heavy-duty plastic material
   (f) Manure: Tapered, durable metal container required
2. **OVERWEIGHT – 60 pound limit**
3. **TRIMMINGS OR LUMBER TOO LONG OR NOT PROPERLY BUNDLED. MUST be 2'x2'x4'.**
4. **GROCERY SACKS MUST BE PLACED IN CONTAINER. HEAVY-DUTY PLASTIC OR PAPER SACKS ARE PERMISSIBLE FOR LIGHT-WEIGHT MATERIALS.**
5. **GARBAGE AND DOG DROPPINGS MUST BE SECURELY WRAPPED IN PAPER OR PLACED IN PLASTIC BAG AND PLACED IN CONTAINER WITH TIGHT-FITTING COVER.**
6. **ASHES – MUST BE DAMP**
7. **SAWDUST AND VACUUM CLEANER DUST MUST BE WRAPPED OR PLACED IN PLASTIC OR PAPER BAGS.**
8. **BUILDING MATERIALS FROM PRIVATE CONTRACTORS WILL NOT BE ACCEPTED.**
9. **ACID, EXPLOSIVES OR OTHER DANGEROUS SUBSTANCES ARE NOT COLLECTED.**
10. **UNACCEPTABLE CONTAINERS:**
    (a) Wooden boxes
    (b) Garden Carts
    (c) Wheelbarrows
    (d) Tarpaulins
    (e) Washtubs
    (f) Wastebaskets
    (g) Containers weighing more than 20 pounds empty

CITY OF BURBANK
PUBLIC WORKS DEPARTMENT
STREET DIVISION

For information: 847-9622

Figure 5. Burbank collection regulations.

Figure 4 above. As required by California state law, the waste is covered daily (hazardous or infectious waste is covered immediately) at the landfill site.

The current landfill is part of the Burbank Reclamation Fill Project which began in 1949. Only city vehicles are permitted to dispose of wastes at the landfill and salvage is not permitted.

Operating personnel at the disposal site consists of four people: a foreman, an equipment operator, a water truck driver, and the weigh station worker.

Administration of the Burbank Solid Waste System

The City of Burbank has a City Manager who is responsible for the operations of the city government. The City Manager reports to an elected council. Under the Manager are several operating and staff departments. One of the departments is the Public Works Department. Each department is composed of divisions. The division responsible for the collection and disposal of residential solid waste is the Sanitation Division. (The operation of the landfill is also the responsibility of the Sanitation Division, while the planning of the landfill site is the responsibility of the City Engineer's office.)

The fee system used in Burbank is a uniform or flat fee. That is, for a single fee, the customer can present for collection an unlimited amount of waste. Currently, the fee is $2.75 per month for a customer in a single-family dwelling and $2.25 per month for an apartment dweller choosing city service. Apartment complexes not electing city service are charged $.90 per month per unit. The last fee change was instituted on August 1, 1974. The city is currently (as of May, 1978) considering another fee increase.

Billing for the service is included on the resident's electric bill. (Electricity in Burbank is provided by the municipality.) Although sufficient data were not available to estimate exactly the incremental cost of billing for the refuse service, it is undoubtedly small since monitoring costs are virtually nil (customers do not have the choice of alternative service levels) and refuse service is mandatory (for those in single-family dwellings).

DATA COLLECTED

As a part of the case study approach, as much data as was available was collected from each of the case study cities. In general, it would be expected that the more complex the fee structure, the greater the amount of data available. That merely reflects one of the administrative costs of a complicated fee structure.

The data available in Burbank can be classified into three categories: data on quantities disposed, data on collection, and data on administration. These categories are described below. The data that are used in our estimation of the effects of user fees are also presented below.

Data on Quantities Disposed

From an analytical viewpoint, the single most important piece of data collected consists of records of the amounts of waste disposed of in Burbank over particular time periods. The City of Burbank has been keeping records of tonnages since June, 1970 and, with the exception of one month when the scale was being relocated, those records are available through December, 1977.

Table 1 presents the data on the quantities of waste disposed at the city owned landfill. As shown in the table, waste quantities are divided into commercial wastes and residential wastes. We were told that 30% of the commercial waste should be classified as residential waste. However, the data shown in the table do not include any adjustment to the figures.

Figure 6 presents the data on residential waste quantities (excluding the 30% commercial waste) over the time period. Note that while the monthly fluctuations are rather great, the mean amount of waste is fairly constant over the period. Two other factors are important, however, in assessing the month-to-month fluctuations in waste generation. First, the number of households from which the waste is collected will influence the totals. Second, the number of working (or actually, collection) days in the month will affect the totals.

Unfortunately, with respect to the number of households, the city was not able to provide figures for more than two points in time. A January, 1970 report states that the number of households was 35,000. A current estimate is that there are approximately 31,000 households. This implies that while total waste generation remained fairly constant, generation per household has been increasing over the period.

Census data on the population of Burbank are obviously not available on an annual or monthly basis. However, population estimates are. Estimates of population for Burbank are shown in Table 2. Using these figures and the annual totals for residential waste generation (excluding and including the 30% factor) provides us with annual per capita estimates as shown in Table 3. As can be seen from the table and the graph of the data in that table (Figure 7), there appears to be a slight increase in the amount of waste per capita over time. (Of course, such analyses will be done more rigorously in the following sections.)

TABLE 1. TONNES OF SOLID WASTE COLLECTED, BURBANK

Date	Residential	Commercial	Date	Residential	Commercial	Date	Residential	Commercial
Jun. 70	2,948	1,165	Jan. 73	2,617	1,097	Jul. 75	3,390	859
Jul. 70	3,074	1,207	Feb. 73	2,451	999	Aug. 75	2,927	732
Aug. 70	2,737	1,152	Mar. 73	2,999	1,121	Sep. 75	3,067	767
Sep. 70	2,671	1,159	Apr. 73	2,910	1,013	Oct. 75	3,207	802
Oct. 70	2,718	1,146	May 73	3,552	1,351	Nov. 75	2,667	667
Nov. 70	2,486	1,114	Jun. 73	2,868	1,082	Dec. 75	2,794	751
Dec. 70	2,667	1,185	Jul. 73	3,078	1,131	Jan. 76	2,548	729
Jan. 71	2,495	1,002	Aug. 73	3,117	1,052	Feb. 76	2,505	646
Feb. 71	2,462	1,101	Sep. 73	2,509	912	Mar. 76	3,077	870
Mar. 71	2,524	1,076	Oct. 73	2,784	1,060	Apr. 76	2,990	791
Apr. 71	2,798	1,257	Nov. 73	2,511	1,001	May 76	3,023	813
May 71	2,742	1,205	Dec. 73	NA	NA	Jun. 76	3,091	794
Jun. 71	2,860	1,236	Jan. 74	2,114	916	Jul. 76	3,131	776
Jul. 71	2,886	1,223	Feb. 74	2,553	1,011	Aug. 76	2,898	766
Aug. 71	2,885	1,103	Mar. 74	2,639	1,071	Sep. 76	3,214	939
Sep. 71	2,901	1,079	Apr. 74	2,857	1,139	Oct. 76	2,730	974
Oct. 71	2,483	922	May 74	2,910	1,030	Nov. 76	2,701	1,001
Nov. 71	2,598	1,112	Jun. 74	2,461	1,016	Dec. 76	2,962	887
Dec. 71	2,627	1,147	Jul. 74	2,636	1,045	Jan. 77	2,818	885
Jan. 72	2,428	993	Aug. 74	2,817	879	Feb. 77	2,559	737
Feb. 72	2,508	937	Sep. 74	2,596	865	Mar. 77	3,016	881
Mar. 72	3,081	1,240	Oct. 74	2,902	974	Apr. 77	2,873	783
Apr. 72	2,590	958	Nov. 74	2,374	795	May 77	3,116	895
May 72	3,044	1,100	Dec. 74	2,834	721	Jun. 77	3,230	932
Jun. 72	3,065	1,166	Jan. 75	2,812	1,007	Jul. 77	2,897	750
Jul. 72	2,672	1,065	Feb. 75	2,437	681	Aug. 77	3,218	896
Aug. 72	2,664	990	Mar. 75	2,943	912	Sep. 77	2,940	810
Sep. 72	2,691	1,005	Apr. 75	2,976	1,028	Oct. 77	2,693	803
Oct. 72	2,720	1,038	May 75	3,275	1,060	Nov. 77	2,703	833
Nov. 72	2,999	1,185	Jun. 75	3,101	845	Dec. 77	2,765	841
Dec. 72	2,333	952						

Source: Burbank Public Works Department.

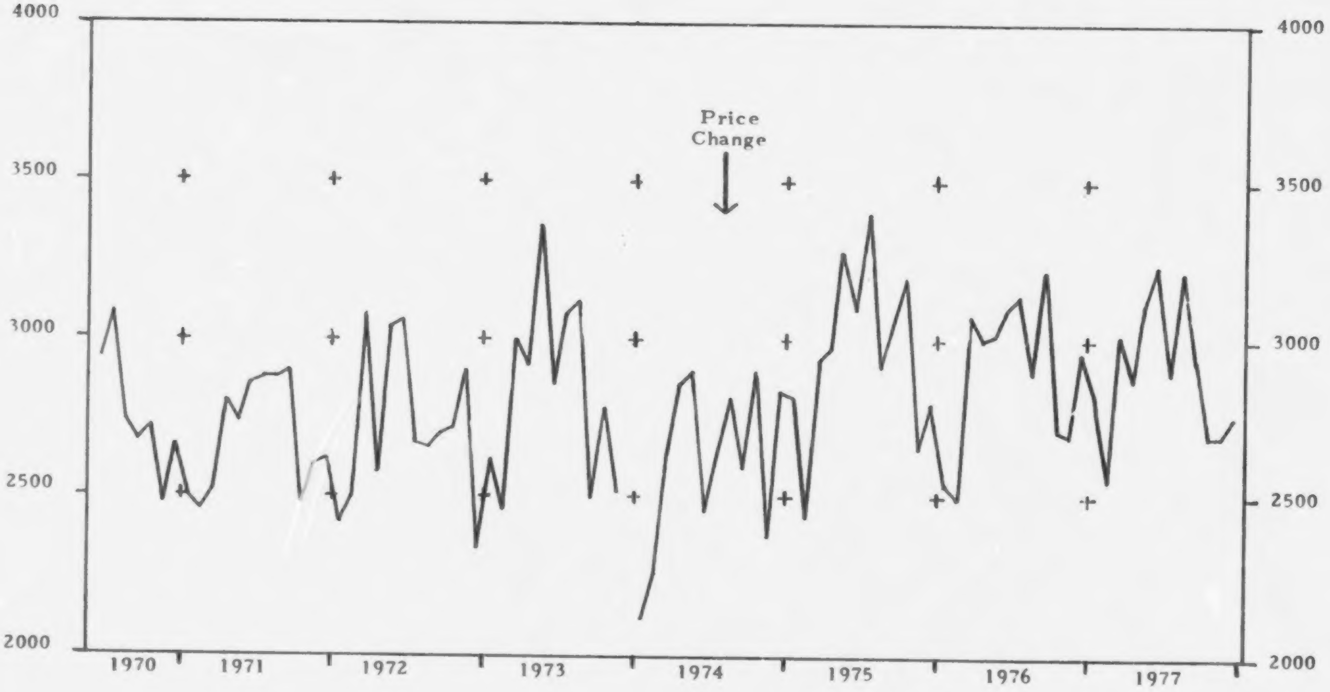


Figure 6. Tonnes of household solid waste collected, Burbank.

TABLE 2. BURBANK POPULATION ESTIMATES

Date	Population
April 70	88,871
July 70	88,600
July 71	87,700
July 72	86,800
July 73	85,800
July 74	85,900
July 75	86,000
July 76	86,100
July 77	86,200

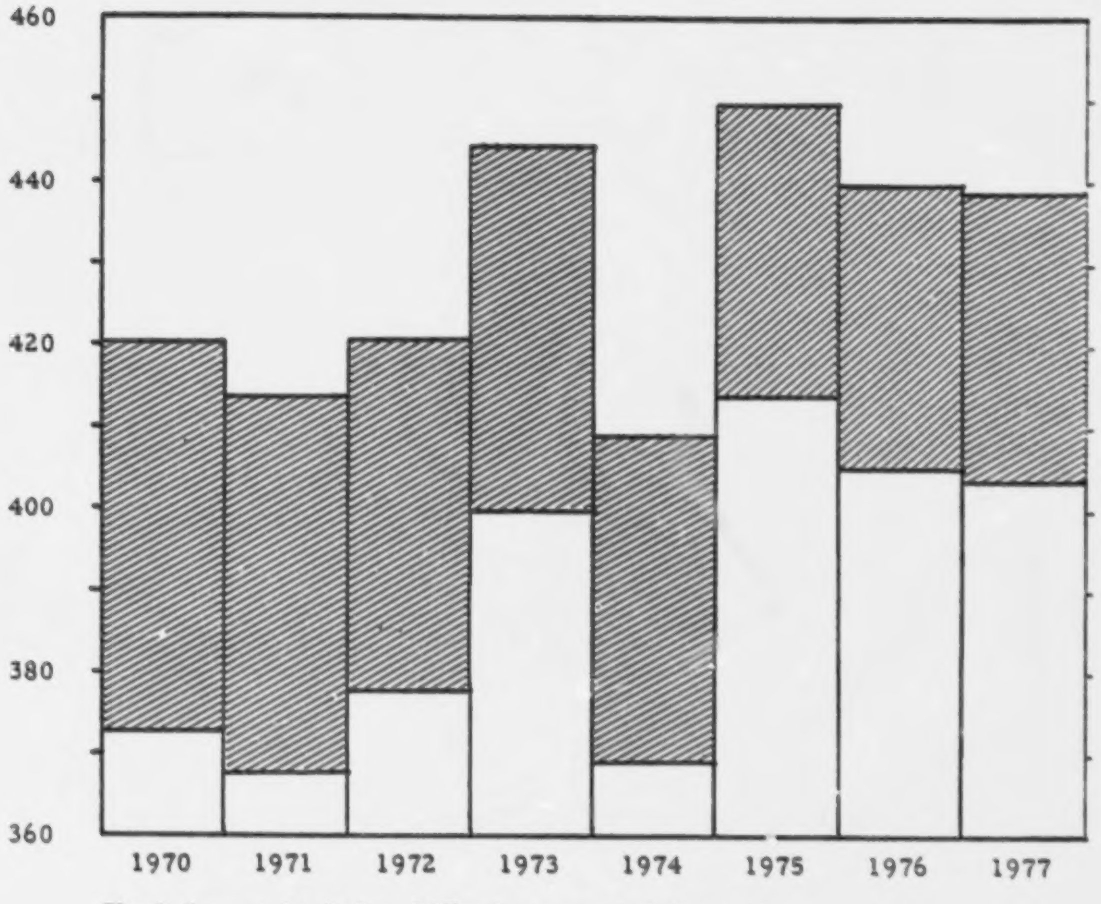
Source: Current Population Reports, U.S. Department of Commerce, Bureau of the Census.

TABLE 3. ANNUAL PER CAPITA RESIDENTIAL WASTE, KGS.

Year	Excluding 30% commercial	Including 30% commercial
1970	373.3	420.5
1971	368.0	414.0
1972	378.2	421.8
1973	399.3	444.3
1974	369.0	409.0
1975	413.9	449.2
1976	404.9	439.7
1977	403.9	438.9

The number of days on which waste was collected was not available for all months for Burbank. However, assuming that collectors receive the same holidays as are usual, an estimate of the working days in each month can be made. Using these estimates of working days in the month, we can estimate daily averages for waste collected. These estimates are shown in Table 4.

In addition to data on quantities for commercial and residential refuse service, data on quantities of waste disposed by other city agencies were available for the two years 1976 and 1977. These quantities are shown in Table 5. While much of these additional data are not used in the analysis, the data on the deposits from the city parks are used in the analysis of the litter question. The remaining data in Table 5 are resented for comparative purposes with the other case studies.



Shaded area includes 30% of commercial waste.

Figure 7. Annual per capita residential waste, kgs.

TABLE 4. AVERAGE DAILY RESIDENTIAL WASTE, BURBANK

Date	Tonnes	Date	Tonnes	Date	Tonnes
Jun. 70	157	Jan. 73	134	Jul. 75	166
Jul. 70	149	Feb. 73	138	Aug. 75	150
Aug. 70	147	Mar. 73	152	Sep. 75	150
Sep. 70	144	Apr. 73	153	Oct. 75	150
Oct. 70	139	May 73	171	Nov. 75	159
Nov. 70	148	Jun. 73	152	Dec. 75	144
Dec. 70	137	Jul. 73	163	Jan. 76	132
Jan. 71	140	Aug. 73	149	Feb. 76	135
Feb. 71	140	Sep. 73	139	Mar. 76	145
Mar. 71	124	Oct. 73	135	Apr. 76	147
Apr. 71	144	Nov. 73	141	May 76	163
May 71	155	Dec. 73	NA	Jun. 76	151
Jun. 71	147	Jan. 74	109	Jul. 76	160
Jul. 71	155	Feb. 74	128	Aug. 76	142
Aug. 71	146	Mar. 74	141	Sep. 76	159
Sep. 71	147	Apr. 74	145	Oct. 76	144
Oct. 71	131	May 74	146	Nov. 76	150
Nov. 71	147	Jun. 74	138	Dec. 76	154
Dec. 71	135	Jul. 74	134	Jan. 77	147
Jan. 72	130	Aug. 74	140	Feb. 77	139
Feb. 72	133	Sep. 74	136	Mar. 77	143
Mar. 72	150	Oct. 74	139	Apr. 77	148
Apr. 72	144	Nov. 74	138	May 77	161
May 72	153	Dec. 74	153	Jun. 77	160
Jun. 72	155	Jan. 75	142	Jul. 77	156
Jul. 72	150	Feb. 75	132	Aug. 77	152
Aug. 72	129	Mar. 75	153	Sep. 77	145
Sep. 72	142	Apr. 75	149	Oct. 77	140
Oct. 72	138	May 75	163	Nov. 77	148
Nov. 72	168	Jun. 75	168	Dec. 77	144
Dec. 72	131				

Source: Burbank Public Works Department.

TABLE 5. TOTAL WASTE COLLECTED FROM MUNICIPAL AGENCIES

Date	Tonnes	Date	Tonnes
Jan. 76	1,503	Jan. 77	1,161
Feb. 76	1,142	Feb. 77	833
Mar. 76	1,834	Mar. 77	2,005
Apr. 76	1,309	Apr. 77	1,447
May 76	1,128	May 77	6,622
Jun. 76	1,110	Jun. 77	1,185
Jul. 76	1,101	Jul. 77	1,253
Aug. 76	1,581	Aug. 77	2,010
Sep. 76	1,470	Sep. 77	840
Oct. 76	1,304	Oct. 77	1,332
Nov. 76	1,279	Nov. 77	1,618
Dec. 76	1,906	Dec. 77	1,358

Source: Burbank Public Works Department.

Data on Collection

The data on collection of wastes in Burbank consists of data on the wages of the personnel, the inventory of trucks, and a route map. The purpose of presenting these data is to provide some basis for comparison with the other cities in the study. However, because we do not have detailed cost records by month, cost functions cannot be estimated and marginal costs or average costs cannot be derived.

As noted earlier, waste is collected five days per week in Burbank. The schedule for collection is as shown in the map in Figure 4 above. The landfill is in the area noted on the map.

The number of personnel and their current salary is shown in Table 6. Personnel staffing has been constant since 1971.

TABLE 6. TOP MONTHLY SALARIES FOR SOLID WASTE PERSONNEL DURING FISCAL YEAR (ENDING 30 JUNE) SHOWN

Year	1973	1974	1975	1976	1977
Collector, 1-man crew	$1,123	$1,199	$1,283	$1,347	$1,417
Collector, 2-man crew	1,065	1,137	1,217	1,278	1,348
Sanitation superintendent	1,427	1,523	1,694	1,894	1,970
Foreman	1,216	1,298	1,405	1,597	1,649
Clerk	677	727	778	816	887

Source: Burbank Public Works Department.

Data on Administration

Administrative data collected from Burbank include fee, budgets, and regulations. The fee schedule for Burbank for the period 1971-1977 are shown in Table 7. Note that there has been one fee change for the period. As we noted in our description of the Burbank solid waste system above, residents are permitted to dispose of unlimited quantities provided only that they are properly containerized. Other regulations that are relevant are shown in Figure 5.

TABLE 7. FEE SCHEDULES

	Before August 1, 1974	After August 1, 1974
Single-family housing	$2.00	$2.75
Multiple-family housing	$1.50	$2.25
Apartments not using service	$ .90	$ .90

Source: Burbank Public Works Department.

EMPIRICAL RESULTS

The Model

Burbank is a flat-fee city. As such, there is no "price" in the sense of an incremental payment for additional service. In theory, a flat fee (or at least a mandatory flat fee with no quantity limits) affects the quantity of waste disposed only through the income effect. That is, payment of the fee reduces the consumer's income but does not affect the relative prices of goods and services.

We hypothesize that the demand for waste collection (measured by quantity disposed), is a function of household income (after collection of the fee) and, possibly, seasonal effects. In other words,

$$Q = f(y, s) \tag{27}$$

where Q is the amount of waste disposed, y is the disposable (after payment of the flat fee) income, and s is a (possibly a vector of) seasonal factor(s).[3] Note that equation (27) contains no socio-economic data other than income, since this study, unlike most previous studies, is a time-series analysis. Therefore, shifts in most of these variables are likely to be small over the period.

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[3] We are, at this point, intentionally avoiding the dimensionality of the variables. This is discussed further below.

In a city such as Burbank, where revenues from the waste collection agency at least cover accounting costs, we would expect that the fee is, at least to some extent, dependent upon the amount of waste collected. That is, there exists a "supply function" where the fee per household represents the average cost per household. We may write this relationship as:

$$\text{FEE} = g\ (Q,\ w) \tag{28}$$

where FEE represents the flat fee and w the wage of the collectors. Equations (27) and (28) represent the system of equations for Burbank.

Estimation

As they are written, equations (27) and (28) are not amenable to econometric analysis. In this section, we specify functional forms for the two relationships and choose some hopefully reasonable surrogates for the variables for which data are not available.

Equation (27) represents the demand for waste collection services. The quantity $(Q\ )$ can be expressed either as: (1) tons per month; (2) monthly tons per capita; or (3) daily tons per capita. All three will be used in the estimation. For the income variable (y), we would like to have total personal income for the City of Burbank. However, at the city level, personal income computations are made only once every five years. Therefore, we have used, as a surrogate, retail sales in the City of Burbank. Data on this series from the State is recorded quarterly, and are provided in Table 8. In the results reported below, the quarterly figure (deflated by the Consumer Price Index) was used in each of the months for the quarter.

TABLE 8. RETAIL SALES TAX COLLECTED, BURBANK

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1971	$45,634	$49,141	$53,834	$61,227
1972	57,446	62,054	63,683	69,354
1973	61,692	73,182	64,839	70,528
1974	66,977	69,946	71,044	77,375
1975	67,694	72,082	71,178	83,753
1976	75,609	84,762	83,444	94,285
1977	90,143	98,134	97,276	107,563

Source: Research and Statistics Division, California Board of Equalization.

Because we do not have data on personal income, either by household or total, an appropriate surrogate for disposable income is unclear. The question becomes: how can the concept of disposable income (i.e., income which reflects the influence of the flat fee) be incorporated into the analysis?

If, for example, a linear demand curve is hypothesized, then the econometric specification of equation (27) is straightforward. It is simply:

$$Q = a + by + cs$$

which can be written as:

$$Q = a + b(m - FEE) + cs \tag{29}$$

where m is before fee disposable income and FEE is the flat fee. Note that in equation (29), we have restricted the coefficients on the income and fee variables to be equal and opposite in sign -- a restriction that follows directly from economic theory.

A second possible, and frequently-used, specification is the double-log formulation. This formulation has the advantage of providing elasticities directly in the form of the coefficients. Such a specification would be as follows:

$$Q = ay^b s^e \tag{30}$$

Expressed in this form, the difficulty of using the surrogate for income becomes immediately apparent. Unlike the linear form, equation (30) cannot incorporate the separate effects of the fee and income and still retain the properties of the double-log formulation.

Because the fee in Burbank is reasonably small relative to income and because we know, by theory, that the income elasticity reflects the impact of fee changes, we will use equation (30) with retail sales as the surrogate for disposable income (after fee) for our estimates of the effect of income (recall that there is no price effect) on waste generation in Burbank.

The use of retail sales as a surrogate for personal income must also be viewed with at least some caution. A finding of a significant relationship between the quantity of waste disposed and the level of retail sales may simply reflect the fact that as people buy more goods, more waste will be generated. Therefore, the usefulness of the retail sales surrogate depends on how closely it reflects personal income for the residents of Burbank.

Empirical Estimates

The basic equation to be estimated for the Burbank case study is:

$$Q = a(RS)^b s^c$$

where RS represents retail sales. Taking logs on both sides,

$$\ln(Q) = \ln(a) + b\ln(RS) + c\ln(s) \tag{31}$$

In this section, we present the results of the econometric investigation of equation (31).

The first step is to select seasonal variables. For the estimation of the equation, we have used dummy variables to represent winter (December, January, and February), spring (March, April, and May), and summer (June, July, and August).

Using monthly totals on waste collected and including the 30% of "commercial" waste that is estimated to be residential, the results of applying ordinary least squares to equation (31) gives (standard errors in parentheses):

$$\underset{}{\ln Q} = 6.18 + \underset{(.11)}{.18\ln RS} - \underset{(.025)}{.06WIN} + \underset{(.025)}{.08SPR} + \underset{(.024)}{.07SUM} \tag{32}$$

$$R^2 = .38$$
$$N = 83$$

As shown in the results of the regression, the coefficient in the income surrogate is not significant at the 95% confidence level (the t-statistic is 1.62, which is, however, significant at the 90% level). Before failing to reject the null hypothesis of no income effect, some additional investigation should be performed. The most plausible reason for the finding of no effect is that the effects of income are felt on waste generation only after some lag. Therefore, we use lagged (by one month) retail sales in the next regression. The results (standard errors in parentheses) are:

$$\ln Q = 5.73 + \underset{(.106)}{.221} \ln(RS)_{-1} - \underset{(.024)}{.058}WIN + \underset{(.024)}{.081}SPR + \underset{(.023)}{.068}SUM$$

$$R^2 = .36$$
$$N = 81$$

The coefficient on the income variable implies an income elasticity of .22 and is statistically significant at the 95% level. This figure is consistent with previous findings (Wertz, Tolley, et al., McFarland, Stevens) as discussed in Section 4.

To check the sensitivity of the results to the particular quantity variable, the results of several other regressions are summarized in Table 9. As shown there, none of the implied income elasticities are significantly different from one another. (All regressions include the same set of independent variables as in equation (32).)

Table 9. ALTERNATIVE INCOME ELASTICITES

	Estimated income elasticity	t-statistic	R^2
Excluding 30% of commercial waste	.221	2.05	.36
Daily totals including 30% commercial	.272	2.83	.28
Daily totals excluding 30% commercial	.273	2.81	.27
Per capita monthly including 30%	.233	2.13	.35

NOTE: For all regressions, the number of observations was 81. The period was February, 1972 to December, 1977 excluding December, 1973 and January, 1974.

These results lend support to previous findings in the range of .2-.4 for the income elasticity. Because this analysis is a time-series analysis we would expect the elasticities estimated to be short-run elasticities and, therefore, somewhat lower than those estimated by cross-sectional analyses.

LITTER EFFECTS AND ADMINISTRATIVE COSTS

Litter

As discussed above, a city which employs a flat-fee structure should not, theoretically, encounter any changes in littering resulting from a fee change. While data on litter were not separately available, data on deposits at the landfill from the Parks Department were available for 1976 and 1977 and were presented in Table 5 above.

A simple test of the litter hypothesis is to see whether these deposits are significantly related to the level of the real fee.[4] Therefore, the following equation was estimated:

$$\ln(L) = b_0 + b_1 \ln(FEE) + b_2 s \qquad (33)$$

where L is the monthly total of Parks Department deposits and FEE is the fee.

The result of the estimation of equation (33) is (standard errors in parentheses):

$$\ln(L) = 5.2 - \underset{(1.2)}{.21} \ln(FEE) + \underset{(.12)}{.01}WIN + \underset{(.12)}{.13}SPR + \underset{(.12)}{.04}SUM$$

$$R^2 = .11$$
$$N = 24$$

As is obvious from the results of the regression, and as would be expected on theoretical grounds, litter is not affected by the fee.

Administrative Costs

One of the advantages of a flat-fee system is its low administrative costs. While data are available on the administration cost with the Sanitation Department (in the form of personnel loading and salaries), the marginal costs of billing are not available.

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[4] Since there was no fee change in the period 1976-77, a test of the impact of a nominal fee change cannot be made.

CONCLUSIONS

The Burbank, California, case study provides an opportunity to empirically assess the income effects on waste generation. Because of the lack of an incremental price, there will be no price effect.

Using the data available from existing records in Burbank, an income elasticity of approximately .22 was estimated. This estimate was found not to be significantly affected by alternative definitions of the waste measure (i.e., per capita vs. total, daily vs. monthly, and including or excluding commercial). An income elasticity of this magnitude is consistent with findings of other studies and is not, *a priori*, unreasonable.

SECTION 6

SACRAMENTO, CALIFORNIA

The City of Sacramento, California allows residents to choose, for a fee, the number of cans to be picked up during regular collections. We have referred to such a system as a container-based fee. Service from the city is mandatory for all residents. The basic service is offered once per week with special collections, for an additional fee, available upon request. As we have discussed above, such a fee system may induce residents to dispose of less waste by imposing an additional fee. In addition, it may induce additional use of illegal disposal methods.

Unfortunately, the data in Sacramento are not detailed enough for us to make a definitive statement about these hypotheses. While good data on the amounts of waste disposed over time are available, other important data items, such as the number of containers chosen, are not. A new management information system was introduced in February 1977, but the data contained in those early months are suspected of being unreliable by individuals in the City's Finance Department.

An important difference in the Sacramento system is the provision for the pickup of lawn and garden refuse. Lawn and garden refuse in Sacramento is not collected by refuse crews. Residents are not required to place their garden waste in containers (except those in areas without curbs), but are required to pile the waste in the street no sooner than one day prior to the scheduled pickup. Thus all references to the solid waste system in this section exclude lawn and garden trash.

The solid waste management system in Sacramento is first described, and the data collected during and since our site visit are then presented. Following that, we discuss the theoretical models to test the hypotheses which we have formulated and which can be tested given the data available. The results of the empirical tests are then reported. Finally, we present the conclusions we can make concerning the effects of container-based fee structures.

THE SACRAMENTO SOLID WASTE SYSTEM

Collection of residential solid waste in Sacramento is accomplished by three-man crews using rear-loading packer trucks. Backyard service is provided to all customers, although some residents do bring their cans outside of the backyard gate to avoid the noise, etc., that accompanies waste collection. The collected waste is hauled to the city landfill located adjacent to the American River, which is reasonably close to the geographic center of the city.

Billing for the service is done by the Utility Billing System of the city. Included on the bill are the water, sewer, refuse, and garden refuse bills.

Collection of Residential Solid Waste in Sacramento

For purposes of residential collection, the City of Sacramento is divided into 32 different routes. (There are a total of 52 routes in Sacramento but some are commerical routes and others are special routes.) One crew is responsible for each route and collects in different segments of the route each day (Monday through Friday) of the week. The majority of trucks used for residential waste collection are 16 to 20 cubic yard rear packers. On most days the collection crew consists of three people, although on days of high absenteeism there may only be two people. One crew member is in charge and has the responsibility of driving the truck between yard (collocated with the landfill) and the route. Once on the route, however, crew members rotate driving. This is because the collectors use 65 gallon tubs and collect from more than one household before returning to the truck.

The reason for the three-man crews is the provision of carryout service to all residents -- a service included in the basic fee. While one-man crews have been considered in Sacramento, resident resistance to placement of refuse on curbs is sufficiently strong to prevent this. (Recall, however, that this does not imply inefficiency in the economic sense of the term.) The passage of Proposition 13 in California, with the consequent search for new sources of revenues (or, equivalently cost-saving alternatives), may change this at some point in the future.

The collection crews are on an individual incentive basis. That is, once the route is completed, the crew may return to the landfill for dumping, park the truck, and leave for the day. Thus, most crews finish early. Collectors are unionized and are members of the Operating Engineers Union.

Currently, about 102,000 households are served in Sacramento. The majority (about 73%) have elected single-can service. Very few elect to have more than two cans collected. Further, while the fee structure allows for cans in excess of 31 gallons, for all practical purposes residents do not choose larger sizes.

Disposal

As noted above, the waste collected by city crews is deposited at the city-owned landfill. The waste is covered daily (with infectious or hazardous waste covered immediately). The garage for the refuse trucks is adjacent to the landfill so that there is little dead time between disposal and return to the garage at the end of the day.

Most routes include two trips to the landfill, with the second at the end of the day. The first trip is also often used for a lunch break.

Administration of the Sacramento System

Responsibility for residential waste collection in the City of Sacramento resides with the Division of Waste Removal, which is part of the City Engineer's Office. A functional organization chart is shown in Figure 8. The chart shows the separate responsibility for collection of residential waste and lawn and garden refuse. While it has been proposed to consolidate the functions, voters in the city have rejected such a proposal.

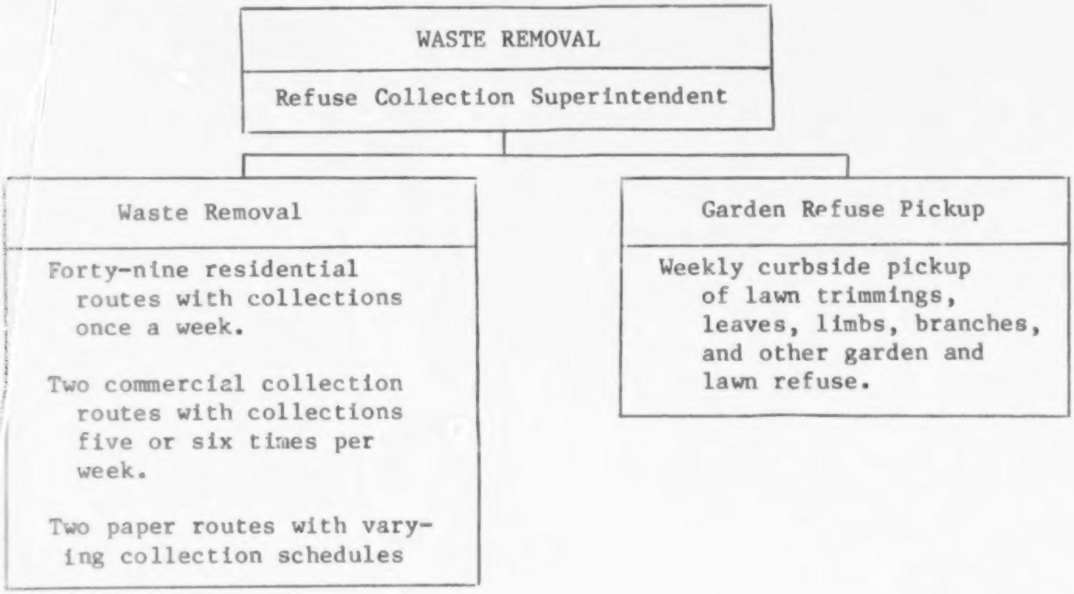

WASTE REMOVAL
Refuse Collection Superintendent
Waste Removal
Forty-nine residential routes with collections once a week.
Two commercial collection routes with collections five or six times per week.
Two paper routes with varying collection schedules
Garden Refuse Pickup
Weekly curbside pickup of lawn trimmings, leaves, limbs, branches, and other garden and lawn refuse.

Figure 8. Functional organization chart.

The fee system in Sacramento is based on the number of containers presented for collection. The current fee schedule is shown in Table 10. While it appears complex, most of the options are designed for commercial customers. Residential customers do not have the option of selecting the number of pickups per week (other than through "special" pickups which require a separate request each time).

Billing for the service is handled by the Utility Billing System. The bill includes water, sewer, refuse, and lawn and garden billings. A sample bill is shown in Figure 9. When new residents enter the city, they select a level of service. The Utility Billing System is then updated. In addition to keeping records for billing, the collection crews must be notified. One clerk in the superintendent's office updates the route books daily, noting starts, stops, and changes in levels of service.

TABLE 10. SACRAMENTO FEE SCHEDULE

NEW RATES - EFFECTIV JULY 1, 1977

MONTHLY CAN RATES

	1 can pickup once a week	2 can pickup* once a week	1 can pickup twice a week	3 coll. per week per can	5 coll. per week per can	6 coll. per week per can
31 gals or less	$3.25	$4.40	$6.80	$7.50	$14.40	$18.70
32 to 40 gals	3.70	5.20	7.50	8.35	17.40	22.60
41 to 50 gals	4.65	5.85	8.35	9.10	20.45	25.90
51 to 60 gals	5.30	6.40	9.05	9.75	23.45	30.50

*Each additional can (31 gallons or less) $1.15 per month

MONTHLY BIN RATES

	1 pickup per week	2 pickups per week	3 pickups per week	5 pickups per week	6 pickups per week
1 Cubic Yd. Bin Loose	$20.85	$34.10	$47.40	$74.00	$93.90
2 Cubic Yd. Bin Loose	27.35	44.00	60.65	93.85	118.75

Included in all of the above rates is a charge of $7.00 per month for rental of a one cubic yard bin and $10.00 per month for rental of a two (2) cubic yard bin.

MONTHLY COMPACTOR RATES

	1 pickup per week	2 pickups per week	3 pickups per week	4 pickups per week	5 pickups per week	6 pickups per week
3 cubic yard	$42.60	$74.55	$106.60	$149.10	$170.55	$218.30
4 cubic yard	56.80	99.40	142.15	198.80	227.40	291.10
5 cubic yard	71.00	124.25	177.70	248.50	284.25	363.90
6 cubic yard	85.20	149.10	213.20	298.20	341.10	436.60

MONTHLY BLANKET RATES

No. of Blankets	1 pickup per week	2 pickups per week	3 pickups per week	5 pickups per week	6 pickups per week
1	$3.50	$6.95	$10.40	$17.50	$22.75
2	6.00	13.95	20.40	32.00	41.55
3	8.90	20.40	29.05	46.50	60.40
4	12.00	26.10	37.75	60.95	79.30
5	15.00	32.00	46.50	75.50	98.15

(continued)

TABLE 10 (continued)

MONTHLY MOBILE HOME PARK RATES[*]

	1 can pickup once a week	2 can pickup once a week	1 can pickup twice a week	3 coll. per week per can
31 gals or less	$2.15	$2.85	$4.55	$5.00
32 to 40 gals	2.50	3.45	5.00	5.60
41 to 50 gals	3.15	3.90	5.60	6.10

[*] For Mobile Home Parks with more than 100 units and cans placed within 25 feet of roadway.

SPECIALS - EFFECTIVE JULY 1, 1977

CANS

Route Special

$1.15 per can (31 gallons or less)

Special

$3.25 for first can (31 gallons or less)
and $1.15 for each additional can (31 gallons or less)

Bins

Route Special

1 cubic yard - $5.15
2 cubic yard - 7.30

Deliver Bin and Pickup

1 cubic yard - $ 7.00
2 cubic yard - 10.25
3 cubic yard - 13.50

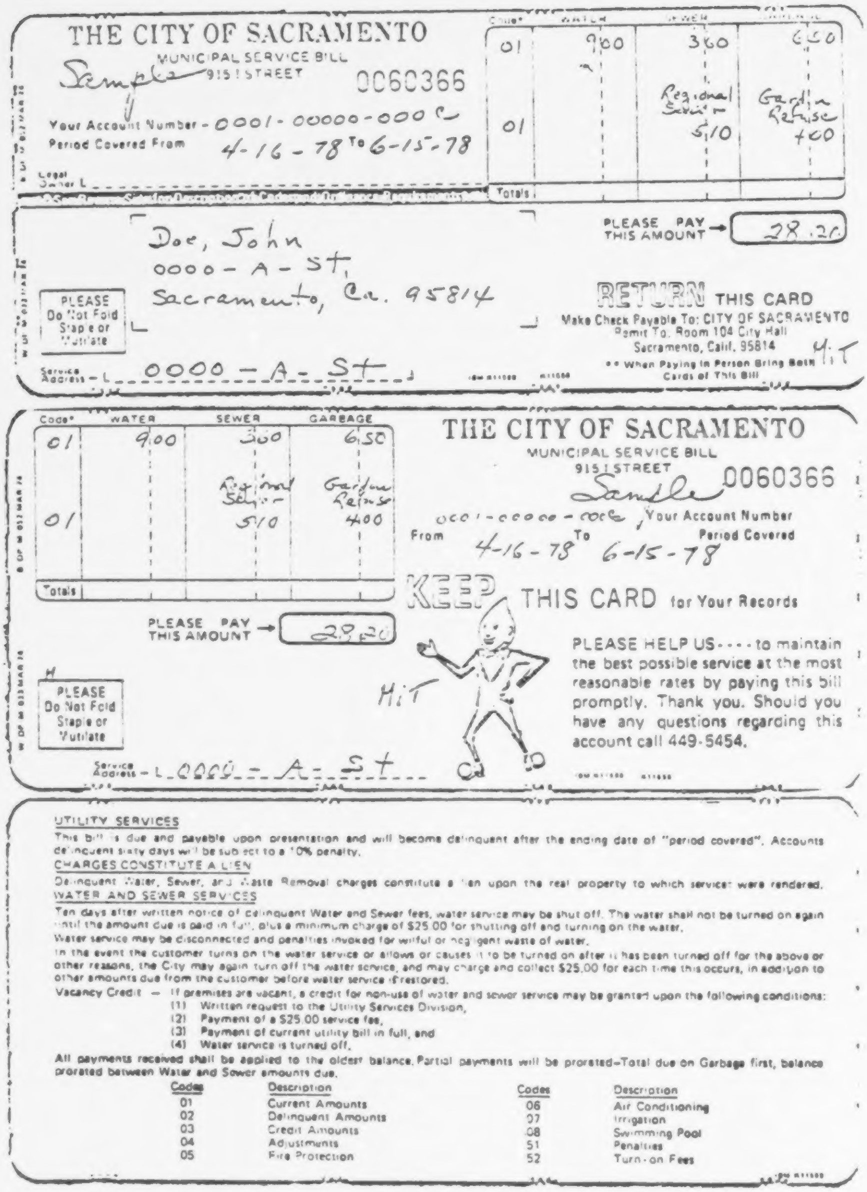
Special Cleanup

$8.65 pr. hour - Time required to remove, load in a truck and haul away rubbish or waste matter.

COMPACTORS

	Weekday	Sat/Sun
3 cu. yd.	$12.25	$18.50
4 cu. yd.	15.25	23.00
5 cu. yd.	18.25	27.50
6 cu. yd.	21.25	31.50

Source: Sacramento Public Works Department.



THE CITY OF SACRAMENTO
MUNICIPAL SERVICE BILL
915 I STREET
Sample
0060366

Your Account Number - 0001-00000-000
Period Covered From 4-16-78 To 6-15-78

Legal Owner

Code*	WATER	SEWER	GARBAGE
01	9.00	3.60	6.50
01		Regional Sewer 5.10	Garden Refuse 4.00
Totals			

PLEASE PAY THIS AMOUNT → 28.20

Doe, John
0000 - A - St,
Sacramento, Ca. 95814

PLEASE
Do Not Fold
Staple or
Mutilate

RETURN THIS CARD
Make Check Payable To: CITY OF SACRAMENTO
Remit To: Room 104 City Hall
Sacramento, Calif. 95814
** When Paying in Person Bring Both Cards of This Bill

M.T

Service Address - 0000 - A - St

Code*	WATER	SEWER	GARBAGE
01	9.00	3.60	6.50
01		Regional Sewer 5.10	Garden Refuse 4.00
Totals			

PLEASE PAY THIS AMOUNT → 28.20

THE CITY OF SACRAMENTO
MUNICIPAL SERVICE BILL
915 I STREET
Sample
0060366

0001-00000-000 , Your Account Number
From 4-16-78 To 6-15-78 Period Covered

KEEP THIS CARD for Your Records

PLEASE HELP US---- to maintain the best possible service at the most reasonable rates by paying this bill promptly. Thank you. Should you have any questions regarding this account call 449-5454.

M

PLEASE
Do Not Fold
Staple or
Mutilate

MiT

Service Address - 0000 - A - St

UTILITY SERVICES

This bill is due and payable upon presentation and will become delinquent after the ending date of "period covered". Accounts delinquent sixty days will be subject to a 10% penalty.

CHARGES CONSTITUTE A LIEN

Delinquent Water, Sewer, and Waste Removal charges constitute a lien upon the real property to which services were rendered.

WATER AND SEWER SERVICES

Ten days after written notice of delinquent Water and Sewer fees, water service may be shut off. The water shall not be turned on again until the amount due is paid in full, plus a minimum charge of $25.00 for shutting off and turning on the water.

Water service may be disconnected and penalties invoked for wilful or negligent waste of water.

In the event the customer turns on the water service or allows or causes it to be turned on after it has been turned off for the above or other reasons, the City may again turn off the water service, and may charge and collect $25.00 for each time this occurs, in addition to other amounts due from the customer before water service is restored.

Vacancy Credit — If premises are vacant, a credit for non-use of water and sewer service may be granted upon the following conditions:
(1) Written request to the Utility Services Division,
(2) Payment of a $25.00 service fee,
(3) Payment of current utility bill in full, and
(4) Water service is turned off.

All payments received shall be applied to the oldest balance. Partial payments will be prorated—Total due on Garbage first, balance prorated between Water and Sewer amounts due.

Codes	Description	Codes	Description
01	Current Amounts	06	Air Conditioning
02	Delinquent Amounts	07	Irrigation
03	Credit Amounts	08	Swimming Pool
04	Adjustments	51	Penalties
05	Fire Protection	52	Turn-on Fees

Figure 9. Sample bill, Sacramento.

DATA COLLECTED

The amount of data available in Sacramento was somewhat greater than for Burbank. This is probably due to two factors: first, the fee system is more complex and therefore requires more information for operation (and, in turn, generates more information); and, second, Sacramento is substantially larger in population than Burbank. Below we present much of the data collected during the site visit related to residential solid waste collection.

Data on Quantities Disposed

Data were available by collection route in Sacramento. The totals for the city, expressed in tonnes per day, are shown in Table 11. The chart in Figure 10 shows the pattern of collection over the period July, 1975 to April, 1978. (Recall that these totals do not include lawn and garden refuse and cannot, therefore, be directly compared with the other case study cities.)

TABLE 11. HOUSEHOLD WASTE COLLECTED, SACRAMENTO

Date	Tonnes/day	Date	Tonnes/day
December 1975	241	March 1977	NA
January 1976	230	April 1977	220
February 1976	223	May 1977	NA
March 1976	229	June 1977	227
April 1976	227	July 1977	228
May 1976	235	August 1977	234
June 1976	222	September 1977	238
July 1976	228	October 1977	228
August 1976	NA	November 1977	235
September 1976	NA	December 1977	246
October 1976	226	January 1978	270
November 1976	232	February 1978	247
December 1976	228	March 1978	245
January 1977	235	April 1978	242
February 1977	226		

Source: Sacramento Public Works Department.

Garden refuse collections are shown in Table 12. These are monthly, not daily. Also shown in Table 12 are deposits in the landfill from the city parks. These data will be used below to address the question of the externality effects of capacity-based fee structures.

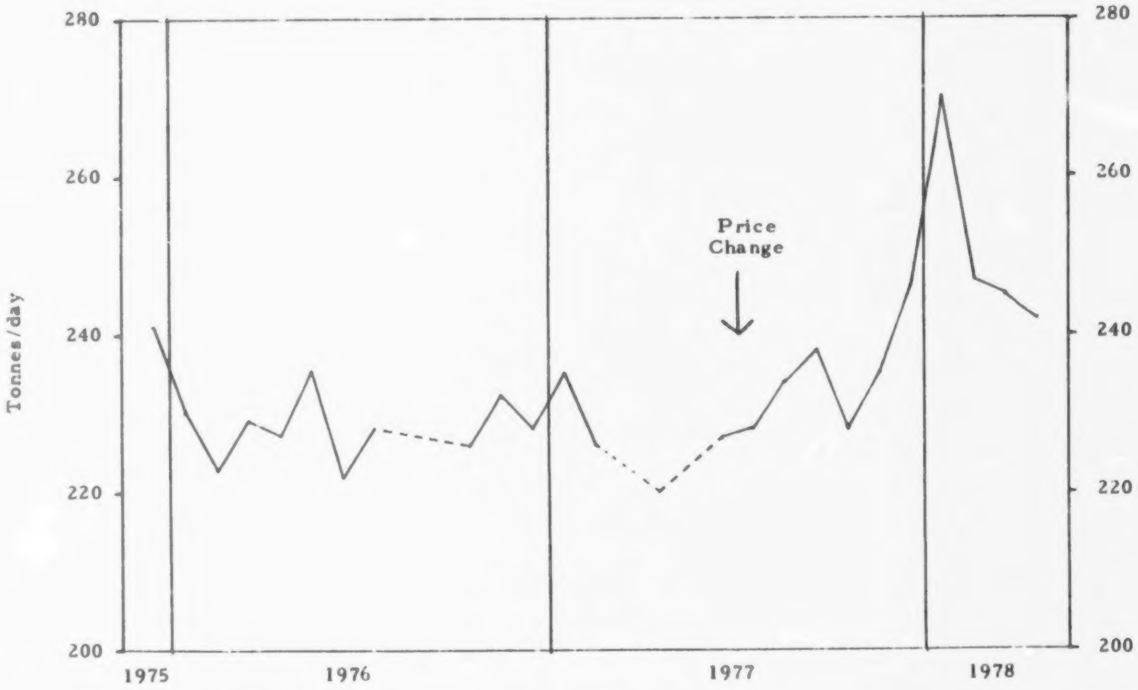


Figure 10. Sacramento household solid waste collected.

TABLE 12. TONNES OF WASTE DISPOSED, SACRAMENTO

Date	Garden waste	Parks	Date	Garden waste	Parks
Jul 1975	2978	418	Dec 1976	4205	271
Aug 1975	2987	531	Jan 1977	4466	415
Sep 1975	3379	438	Feb 1977	2732	439
Oct 1975	4018	444	Mar 1977	2892	502
Nov 1975	4534	462	Apr 1977	3299	NA
Dec 1975	5230	544	May 1977	3337	NA
Jan 1976	3214	504	Jun 1977	3019	262
Feb 1976	2499	454	Jul 1977	2715	354
Mar 1976	3888	463	Aug 1977	3115	373
Apr 1976	4246	365	Sep 1977	3164	350
May 1976	4290	294	Oct 1977	3247	365
Jun 1976	3624	388	Nov 1977	5131	295
Jul 1976	3438	396	Dec 1977	6267	305
Aug 1976	3506	377	Jan 1978	3780	625
Sep 1976	3775	335	Feb 1978	3670	600
Oct 1976	3574	331	Mar 1978	4466	355
Nov 1976	5050	286	Apr 1978	5287	325

Source: Sacramento Public Works Department.

Collection Data

The data obtained on the collection of waste in Sacramento consists of data on labor used. Table 13 lists the current salary schedule for the Sanitation Division. Below, the personnel loading for the Division is given.

Administrative Data

A functional organization chart was given in Figure 8 above. The detailed chart for the Division of Waste Removal is shown in Figure 11. Note the separation between the collection of residential solid waste and yard and garden waste (collected under the heading of street refuse). As shown in the figure, there are 199 people directly associated with the collection of solid (including commercial) waste. The current salary schedules are shown in Table 13.

As noted above, the fee system in Sacramento is one in which the resident chooses the number of containers to be picked up each week. For all practical purposes, the choice is between one can and two and, of this, almost all residents choose containers of 31 gallons or less. The fee schedules for recent years is shown in Table 14. Note that fee changes have been more frequent than in Burbank.

TABLE 13. SALARY RANGE FOR WASTE REMOVAL PERSONNEL

	STEP A	STEP B	STEP C	STEP D	STEP E
REFUSE COLLECTOR	$ 883.00		$ 974.00		$1075.00
REFUSE COLLECTOR TRUCK DRIVER	$ 995.00		$1054.00		$1165.00
WASTE REMOVAL FOREMEN	$1174.00	1232.00	$1295.00	$1359.00	$1427.00
WASTE REMOVAL ASSISTANT SUPERINTENDENT	$1768.00	$1856.00	$1950.00	$2047.00	$2149.00
WASTE REMOVAL SUPERINTENDENT	$2272.00	$2387.00	$2506.00	$2631.00	$2763.00
JUNIOR TYPIST CLERK	$ 659.00	$ 692.00	$726.00	$763.00	$ 801.00
INTERMEDIATE TYPIST CLERK	$ 723.00	$759.00	$797.00	$837.00	$ 879.00
SENIOR TYPIST CLERK	$ 823.00	$865.00	$908.00	$953.00	$1002.00
FIELD REPRESENTATIVE	$ 920.00	$ 967.00	$1016.00	$1066.00	$1120.00
ADMINISTRATIVE ASSISTANT I	$1236.00	$1298.00	$1362.00	$1430.00	$1501.00

Source: Sacramento Public Works Department.

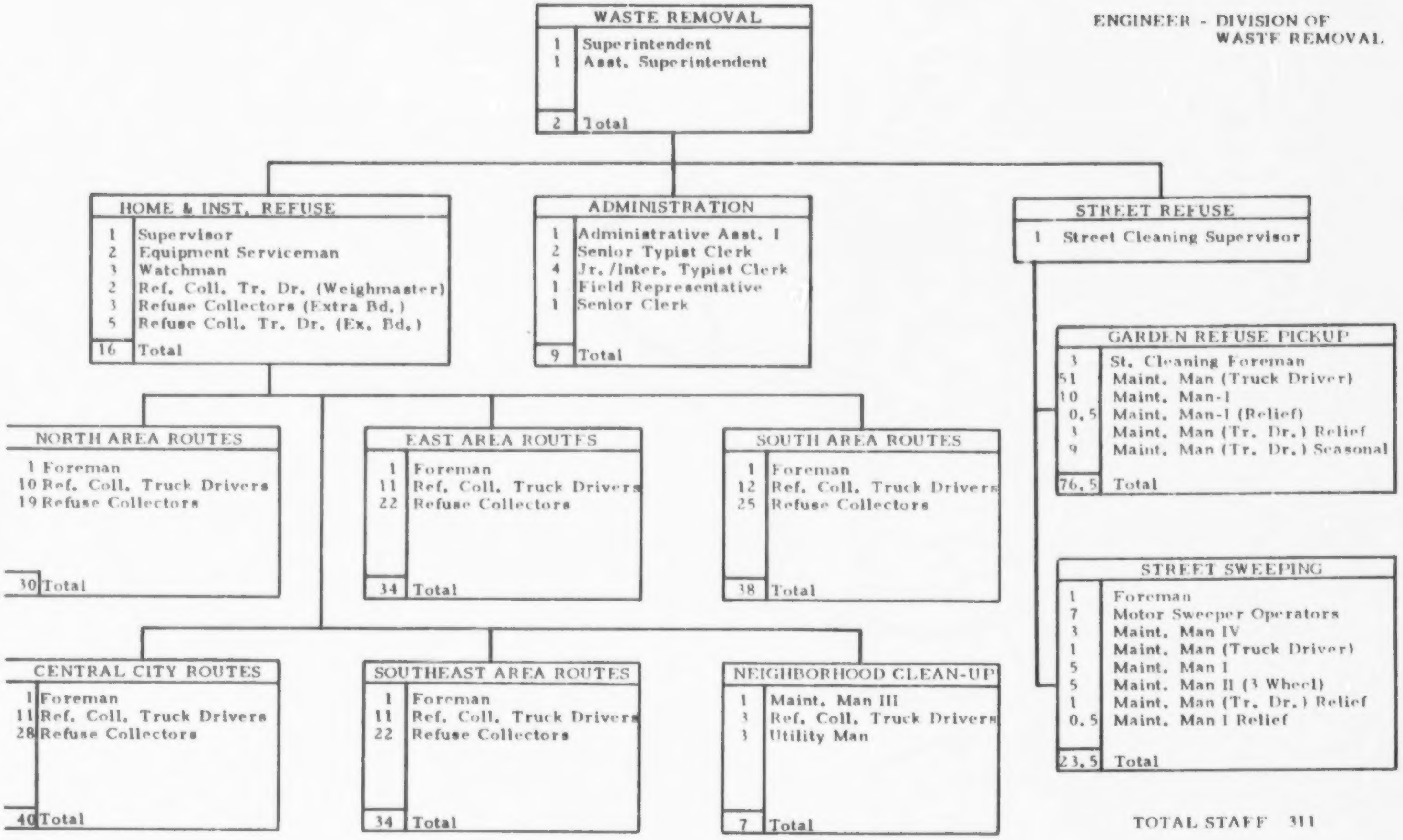

ENGINEER - DIVISION OF WASTE REMOVAL
WASTE REMOVAL
1 Superintendent
1 Asst. Superintendent
2 Total
HOME & INST. REFUSE
1 Supervisor
2 Equipment Serviceman
3 Watchman
2 Ref. Coll. Tr. Dr. (Weighmaster)
3 Refuse Collectors (Extra Bd.)
5 Refuse Coll. Tr. Dr. (Ex. Bd.)
16 Total
ADMINISTRATION
1 Administrative Asst. I
2 Senior Typist Clerk
4 Jr./Inter. Typist Clerk
1 Field Representative
1 Senior Clerk
9 Total
STREET REFUSE
1 Street Cleaning Supervisor
GARDEN REFUSE PICKUP
3 St. Cleaning Foreman
51 Maint. Man (Truck Driver)
10 Maint. Man-I
0.5 Maint. Man-I (Relief)
3 Maint. Man (Tr. Dr.) Relief
9 Maint. Man (Tr. Dr.) Seasonal
76.5 Total
STREET SWEEPING
1 Foreman
7 Motor Sweeper Operators
3 Maint. Man IV
1 Maint. Man (Truck Driver)
5 Maint. Man I
5 Maint. Man II (3 Wheel)
1 Maint. Man (Tr. Dr.) Relief
0.5 Maint. Man I Relief
23.5 Total
NORTH AREA ROUTES
1 Foreman
10 Ref. Coll. Truck Drivers
19 Refuse Collectors
30 Total
EAST AREA ROUTES
1 Foreman
11 Ref. Coll. Truck Drivers
22 Refuse Collectors
34 Total
SOUTH AREA ROUTES
1 Foreman
12 Ref. Coll. Truck Drivers
25 Refuse Collectors
38 Total
CENTRAL CITY ROUTES
1 Foreman
11 Ref. Coll. Truck Drivers
28 Refuse Collectors
40 Total
SOUTHEAST AREA ROUTES
1 Foreman
11 Ref. Coll. Truck Drivers
22 Refuse Collectors
34 Total
NEIGHBORHOOD CLEAN-UP
1 Maint. Man III
3 Ref. Coll. Truck Drivers
3 Utility Man
7 Total
TOTAL STAFF 311

Figure 11. Detailed organization chart, Sacramento.

TABLE 14. RESIDENTIAL COLLECTION FEES, SACRAMENTO

Effective date	1 Can per week	2 Cans per week
16 Aug. 1974	\$2.30	\$3.40
1 Oct. 1975	3.00	4.00
1 July 1977	3.25	4.40

Source: Sacramento Public Works Department.

The fee change of October 1975 actually resulted in a reduction of the incremental fee from \$1.10 per month to \$1.00 per month. The growth in the nominal flat fee (or basic one-can charge) has averaged about 12% annually over the three years 1974-1977, while the growth in the incremental fee has averaged about 9% annually.

EMPIRICAL RESULTS

The Model

With a container-based fee, the resident makes two distinct, although related, choices. First, based on the fee per can the decision on the number of cans of service is made. Second, given the number of cans selected, the decision about the amount of waste to generate is made. These related decisions can be modeled as follows:

$$Q = f(C, y, s) \tag{34}$$

$$C = g(p, y) \tag{35}$$

where Q is the amount of waste disposed, C is the number of containers selected, y is disposable income (again after payment of any mandatory fee), s represents seasonal factors, and p is the price of an incremental can of service.

As with Burbank, it would normally be expected that the level of the fee would depend on the amount of waste generated. Such a dependence could be symbolically described by:

$$p = h(Q, w) \tag{36}$$

where w represents, say, collectors' wages.

In theory, then, the set of functions (34) - (36) provides a system of equations for assessing the effects of an incremental user fee.

Estimation

Given sufficient data, the system of equations (34) - (36) could be estimated using two-stage least squares. In this section, we describe the modifications to the theoretical specification which are necessary to make because of data limitations. To make these modifications, we first specify functional forms for the equations.

With respect to the waste generation equation (equation (32)), we again hypothesize a double-log specification, or

$$Q = aC^b y^c s^d \tag{37}$$

Similarly, a double-log specification is assumed for the demand for containers. Given that assumption, equation (35) becomes:

$$C = ep^f y^g \tag{38}$$

The first modification which is required is caused by the lack of data on the number of residents choosing two-can service. We therefore substitute equation (38) into (37) to obtain

$$Q = a\,(ep^f y^g)^b y^c s^d \tag{39}$$

or

$$Q = a'p^{f'} y^{g'} s^d \tag{40}$$

where the primes indicate the new constants.

The second modification we make deals with the simultaneous nature of the system (34) - (36). Theoretically, simultaneous methods (e.g., two-stage least squares) should be applied to incorporate the simultaneity. However, given the data available in Sacramento, little error is introduced by applying ordinary least squares to (40) alone. The reason is that quantity data are available for only a relatively short period (July, 1975 to April, 1978). During that time, the staff of collectors has remained constant. Therefore, the cost associated with refuse collection is tied almost directly to wages and only slightly, if at all, to the quantity of waste disposed. For this reason, equation (40) alone will be estimated to derive elasticities.

Empirical Estimates

The basic equation to be estimated is:

$$Q = ap^{b}y^{c}s^{d}$$

Taking logs on both sides gives:

$$\ln(Q) = \ln(a) + b\ln(p) + c\ln(y) + d\ln(s) \qquad (41)$$

Again, as with Burbank, we use dummy variables to represent three of the four seasons. Further, a surrogate is required again for the income variable. We use retail sales in the City of Sacramento. The basic one-can fee is not subtracted since it is small relative to income and no true income variable is available.

The data on retail sales in Sacramento are shown in Table 15. For purposes of the analysis, we assume that the monthly totals are equal to the value in the quarter.

TABLE 15. RETAIL SALES TAX COLLECTED: SACRAMENTO

Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
1974	$202,993	$235,733	$253,034	$249,047
1975	216,400	251,632	265,955	269,443
1976	250,440	279,356	293,017	305,091
1977	288,050	324,500	345,745	350,153

Source: Research and Statistics Division, California Board of Equalization.

Using the data described above, the following results (standard errors in parentheses) were obtained after applying OLS to equation (41):

$$\ln Q = 4.7 + \underset{(.07)}{.09}\ln(RS) + \underset{(.09)}{.23}\ln(p) + \underset{(.01)}{.01}WIN - \underset{(.02)}{.01}SPR - \underset{(.01)}{.02}SUM \qquad (42)$$

$R^2 = .40$

$N = 26$

There are three important results to note. First, the income elasticity, while positive, is insignificantly different from zero (significant at the 20% level). Second, the price elasticity is positive -- and significant. Third, the seasonal dummies are not significant.

Because the existence of a positive price elasticity is theoretically implausible, the results in equation (42) are analyzed further. The first step is to recognize that, as with Burbank, the effect of income and price changes may occur only after some lag. The effect of lagging retail sales and incremental price by one period (standard errors in parentheses) is:

$$\ln Q = 3.6 + \underset{(.08)}{.20} \ln(RS)_{-1} + \underset{(.10)}{.22} \ln(p) + \underset{(.01)}{.01} WIN + \underset{(.02)}{.02} SPR - \underset{(.01)}{.01} SUM \qquad (43)$$

$$R^2 = .50$$
$$N = 22$$

Performing this regression results in a positive and significant income elasticity of .20. However, the problem of a positive and significant price elasticity remains.

Because the price variable used is deflated by the CPI and, for several months, the nominal fee is unchanged, the effect is that the incremental fee may be acting as a trend variable. To check this possibility, we substitute a trend variable for the seasonal dummies. When this is done, the results (standard errors in parentheses) are:

$$\ln(Q) = 1.95 + \underset{(.12)}{.35} \ln(RS) + \underset{(.09)}{.09} \ln(p) - \underset{(.001)}{.002} T$$

$$R^2 = .48$$
$$N = 22$$

The effect of this substitution is to retain the positive, and significant income elasticity (although the magnitude of the elasticity has increased to .35). While the price elasticity is again positive, it is insignificantly different from zero. Further, while the R^2 is about the same as before, the number of variables is fewer making the regression significant at a higher level.

LITTER AND ADMINISTRATIVE COSTS

Litter

Elasticities estimated above are related to quantity of waste presented for collection. The price effects on quantity of waste generated will be the same as on quantity collected only if no substitutes for municipal collection are available. It has sometimes been argued that user charges which vary according to quantity of waste collected provide an incentive for households to seek substitutes such as littering which have unacceptably high social costs.

No direct measure of quantity of litter was available in Sacramento. Quantity of waste disposed at the landfill by the Parks Department (Table 12) was used as a proxy for quantity of litter on grounds that some illicitly disposed household waste will be dumped in parks and show up over and above some base quantity. To test the hypothesis that quantity of litter is related to the level of the user fee, the following equation was estimated:

$$\ln(L) = b_0 + b_1 \ln(p) + b_2 s \tag{44}$$

where L is the monthly total of parks waste, p is the real price of an incremental can, and s is a seasonal dummy variable.

The results (standard errors in parentheses) were:

$$\ln(L) = 6.7 + \underset{(.77)}{1.53} \ln(p) + \underset{(.10)}{.17}WIN + \underset{(.12)}{.15}SPR + \underset{(.10)}{.04}SUM$$

$$R^2 = .19$$
$$N = 28$$

The coefficient for real price is significant here at the 95% confidence level (t-statistic = 1.99) and of the expected sign. However, this may be due to a time trend such as improved litter collection operations. To test this further hypothesis, the following equation was estimated:

$$\ln(L) = b_0 + b_1 \ln(p) + b_2 (T) + b_3 s \tag{45}$$

where T is a time series and other variables are as before. The results (standard errors in parentheses) were:

$$\ln(L) = 6.9 + \underset{(.65)}{.74} \ln(p) - \underset{(.004)}{.012}T + \underset{(.09)}{.14}WIN + \underset{(.11)}{.09}SPR + \underset{(.08)}{.03}SUM$$

$$R^2 = .43$$
$$N = 28$$

In this case only the coefficient for the time variable is significant.

Another test of the litter hypothesis would be to suppose that household refuse was disposed with garden waste in response to price increases. To test this hypothesis the following equation was estimated:

$$\ln(G) = b_0 + b_1 \ln(p) + b_2 s \qquad (46)$$

where G is monthly quantity of garden waste and other variables are as before. The mandatory fee for garden refuse collection remained constant throughout the period considered and hence does not enter into the equation. The results (standard errors in parentheses) were:

$$\ln(G) = \underset{}{8.4} - \underset{(.80)}{.05 \ln(p)} - \underset{(.11)}{.01 WIN} - \underset{(.12)}{.08 SPR} - \underset{(.10)}{.22 SUM}$$

$$R^2 = .17$$
$$N = 30$$

Only the dummy variable for summer was significant.

Sacramento does not allow individuals to haul their own household refuse to the landfill and dispose of it there. While the two alternative methods of disposal we have explored here are imperfect measures of illicit disposal at best, the conclusion indicated -- that price changes in the user fee affect neither quantities of refuse generated nor quantities presented for collection -- are not contradicted by observations or remarks of personnel in the Division of Waste Removal.

Administrative Costs

Administrative costs associated with the container-based fee structure include costs of billing, including both maintaining billing records and processing bills, and keeping records of starts, stops, and changes in service levels. Unfortunately, data were not available in Sacramento which would allow an evaluation of these costs.

SECTION 7

PROVO, UTAH

Among cities with user fees for household solid waste collection, relatively few employ a variable fee structure based exclusively on pickup location, charging one rate for backyard service and another rate for curbside service. According to the data in Appendix A, only two percent of the cities employ such a structure. Provo, Utah, is one such city. Residents of Provo may choose between paying $2.50 per month for curbside collection and paying $5.00 per month for backyard collection.

In the model for a service-based fee presented in Section 4, the price of service affected the amount of waste generated via service level. Unfortunately, the lack of data in Provo makes it impossible to estimate the model's demand specifications. Available data lend some support to existing evidence of positive income elasticities for solid waste services, although this support is weakened by the nature of the data.

In this section we first describe the solid waste system in Provo and the data which were collected. These data are then used to test some hypotheses generated by the service-based model and the results are presented.

THE PROVO SOLID WASTE SYSTEM

Solid waste collection and disposal in Provo is carried out by a department of city government, the Department of Sanitation, and residents are billed monthly for this service along with electric, water, and sewage bills. Frequency of residential collection is once a week, and city collection is mandatory for all residents. Most commercial firms also use city collection, although the largest single producer of solid waste, Brigham Young University, hauls its own waste to the city landfill, paying only for disposal.

About a third of Provo's residents are students and their families; this has at least two important consequences for solid waste collection. First, extra solid waste is produced at the beginning and end of each school term as students move in or out. Quantitative figures are not available on the degree of this effect, but it is noticeable to personnel in the Sanitation Department. Second, a high proportion of housing units are rented rather than owner-occupied in order to accommodate students living off campus. Out of 16,725 units in Provo in January 1978, 7,694 were owner-occupied and 9,031 were rented. About 40% of the rental units are duplexes, and most of the rest are apartments. In some apartment blocks refuse is collected from each unit separately, while in others collection and billing is consolidated through using large containers. Again, exact figures are not available, but it appears that apartment units are evenly divided between the two arrangements. Altogether there are 11,000 residential collection accounts out of a total of 13,000.

Collection of Residential Waste in Provo

Collection is made by a fleet of eight packer trucks owned by the Sanitation Department and operated by three-man crews. Three of the trucks are front-loading packers serving commercial customers who rent containers ranging in size form 2 to 8 cubic yards, including apartment blocks. The other six trucks are 25 cubic yard, front-loading packers, one of which serves a commercial-industrial route, and five of which serve residential routes. Crews on residential routes work a five day week and are not affiliated with any union.

The choice between backyard and curbside service was originally intended as a way of providing the elderly and disabled with the convenience of carryout service. In practice, however, any resident with a backyard has this choice. About 3% of all household customers elect to pay the higher fee. Households demanding backyard service do not generally include the elderly and disabled; rather, they are found in areas with higher property values and household incomes. Such residents are widely regarded in the Sanitation Department as taking advantage of a service intended for others, one of several complaints the Department has about the service.

Carryout service is felt to be costly in terms of time -- Department Superintendent John Farley estimates that between 10 and 15 curbside pickups could be made in the time it takes to make one backyard collection. The service is also felt to increase the risk of property damage or personal injury borne by both customers and collectors due to such things as parked cars and other obstacles in the collector's path and mistaken removal of items left near rubbish containers. Consequently, the Sanitation Department does not particularly encourage households to ask for carryout service, although it does not refuse such requests. The Department has been trying unsuccessfully for at least four years to end the carryout option, but the three-member City Commission responsible for such policy decisions has declined to eliminate the service.

Disposal of Solid Waste in Provo

The Sanitation Department maintains a sanitary landfill for solid waste disposal located in an industrial area near the south freeway entrance to the city. All solid waste collected by the Department is deposited in the landfill, and it is open to households and commercial users, but only solid waste originating in the city may be deposited. Households and firms on contract with the city may use the landfill free of charge; all others are charged a fee of $1.96 per cubic meter or $6.61 per tonne.

Although scales are not operated at the landfill, it is estimated that about 218 tonnes of solid waste per working day are deposited at the landfill. At this rate, given current operating methods, the site is expected to reach capacity in two or three years. After that time refuse material would have to be stacked above the present ground level; in addition, the water table is high near the site and ground water infiltration is a continual problem. At present there is no functioning resource recovery system in Provo or Utah County, and any alternative landfill site would probably be outside the city. The solution which is prsently being pursued is the acquisition of a baler which will compact solid waste to a greater density, allowing the life of the landfill to be extended by five to eight years beyond current estimates.

Administration of the Solid Waste System

Provo is the smallest city among our five case studies, and the administrative structure of its solid waste operations is correspondingly the least complex. Only three or four employees act in an administrative or supervisory capacity, and they are closely involved with day-to-day operations of collection, disposal, and equipment maintenance. The advantage of this type of operation is a probable reduction in administrative costs. For example, collectors do not use route books to remind them which customers subscribe to carryout service; locations of carryout residences are simply memorized. Billing is done by a separate office of municipal government together with billing for water, sewage, and electricity. The Sanitation Department is charged $924 a month for this service, although the billing office estimates its cost for this service to be about $150 a month more than that. Depending on whether the lower or higher figure is used, this translates to an annual cost of 8.4¢ or 9.8¢ per household, which is 3.2% to 3.8% of revenue from households.

Unfortunately, the same administrative features mean that data available in other cities about solid waste systems are not available in Provo. Surveys of quantities collected are undertaken periodically, usually in connection with reviews of rates for collection service, and surveys of the location of residential customers are undertaken when a need for re-routing is perceived, but continuous records are not kept and outdated survey data are not systematically preserved.

Occasionally the absence of data may result in added costs. In 1976 a study undertaken by one member of the Department revealed that the city was losing about $12,000 per year from its solid waste collection operations at BYU. This was pointed out to the city commission in a report containing alternative price schedules for collection operations at BYU which would cover the city's costs. As a result, BYU rejected the higher prices and now hauls its own rubbish, paying the normal commercial rate for disposal.

DATA COLLECTED

No permanent records are kept in Provo of quantities of solid waste collected or disposed. However, between August 1976 and January 1977 estimates were made of tonnage collected. Information available from these estimates are shown in Table 16 for residential collection routes. Figure 12 shows districts of the city from which collections are made on each working day. Cross-sectional comparisons may be made by comparing these districts with census tracts shown in Figure 13. Because of rapid growth between 1970 and 1977, such analysis may be misleading, however.

TABLE 16. TONNES/DAY, RESIDENTIAL COLLECTION
AUGUST 1976 THROUGH JANUARY 1977

Truck no.	Mon.	Tue.	Wed.	Thu.	Fri.	Total
831	8.29	4.87	7.35	8.78	9.09	38.38
832	3.26	3.10	1.67	2.29	3.03	13.34
833	9.97	7.00	8.89	8.75	8.82	43.42
834	10.71	5.66	6.65	7.61	7.58	38.22
835	9.90	5.68	4.85	9.39	10.18	40.00

Source: Provo Sanitation Department.

Data on numbers of households selecting curbside and backyard service were available from billing records. Table 17 shows numbers of households in single-unit structures receiving each level of service for each of four billing districts during the last week of April 1977 and 1978. Location of the billing districts is shown in Figure 14.

TABLE 17. NUMBER OF CUSTOMERS SELECTING CURB AND BACKYARD SERVICE

Billing district:		I	II	III	IV	Total
1977	Curb	1313	2670	1389	2180	7552
	Rear	157	104	26	24	311
	% Rear	10.7	3.7	1.8	1.1	4.0
1978	Curb	1366	2811	1344	2341	7862
	Rear	143	98	46	31	318
	% Rear	9.5	3.4	3.3	1.3	3.9

Source: Billing Department, Provo City Power Company.

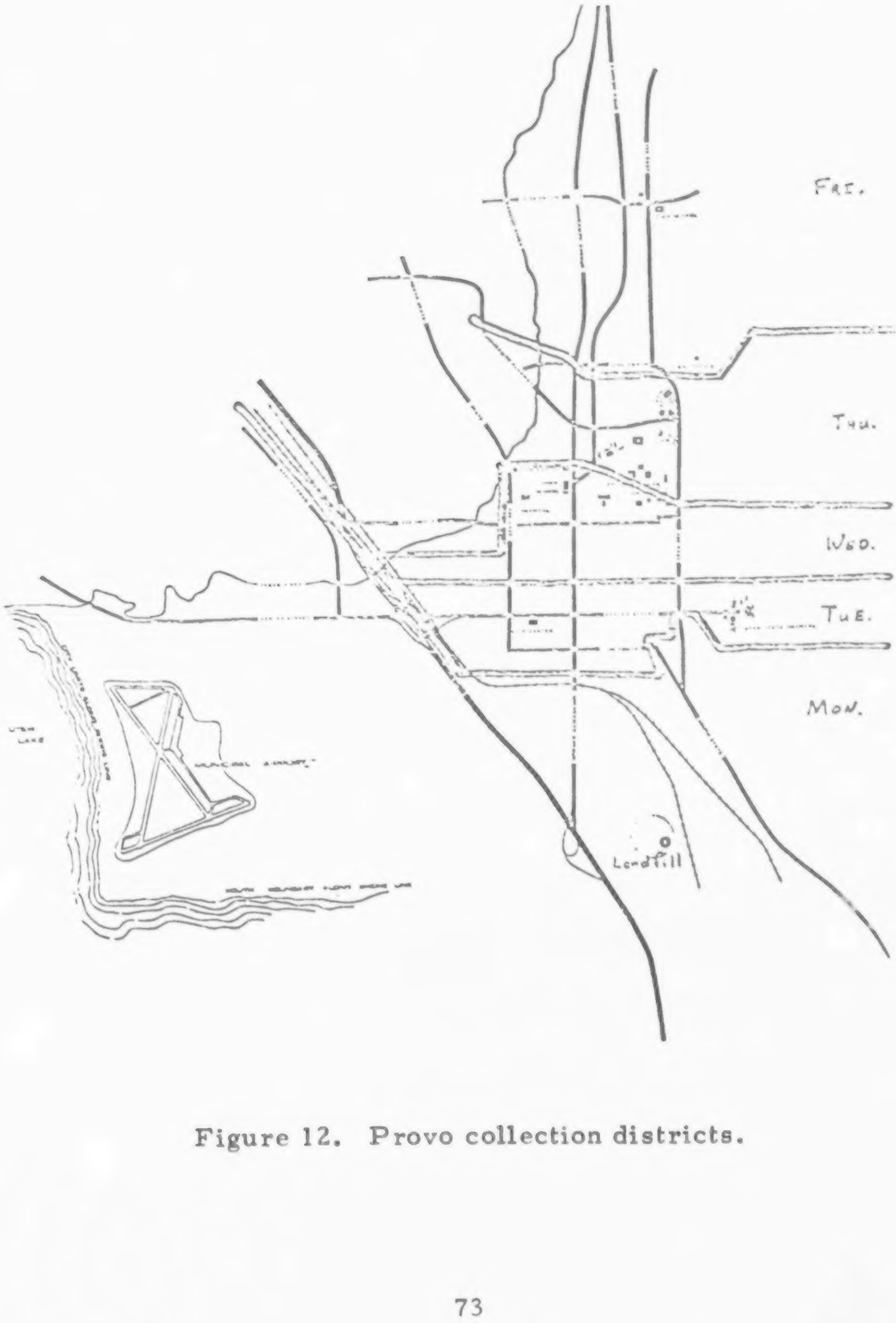

FRI.
THU.
WED.
TUE.
MON.
UTAH LAKE
MUNICIPAL AIRPORT
Landfill

Figure 12. Provo collection districts.

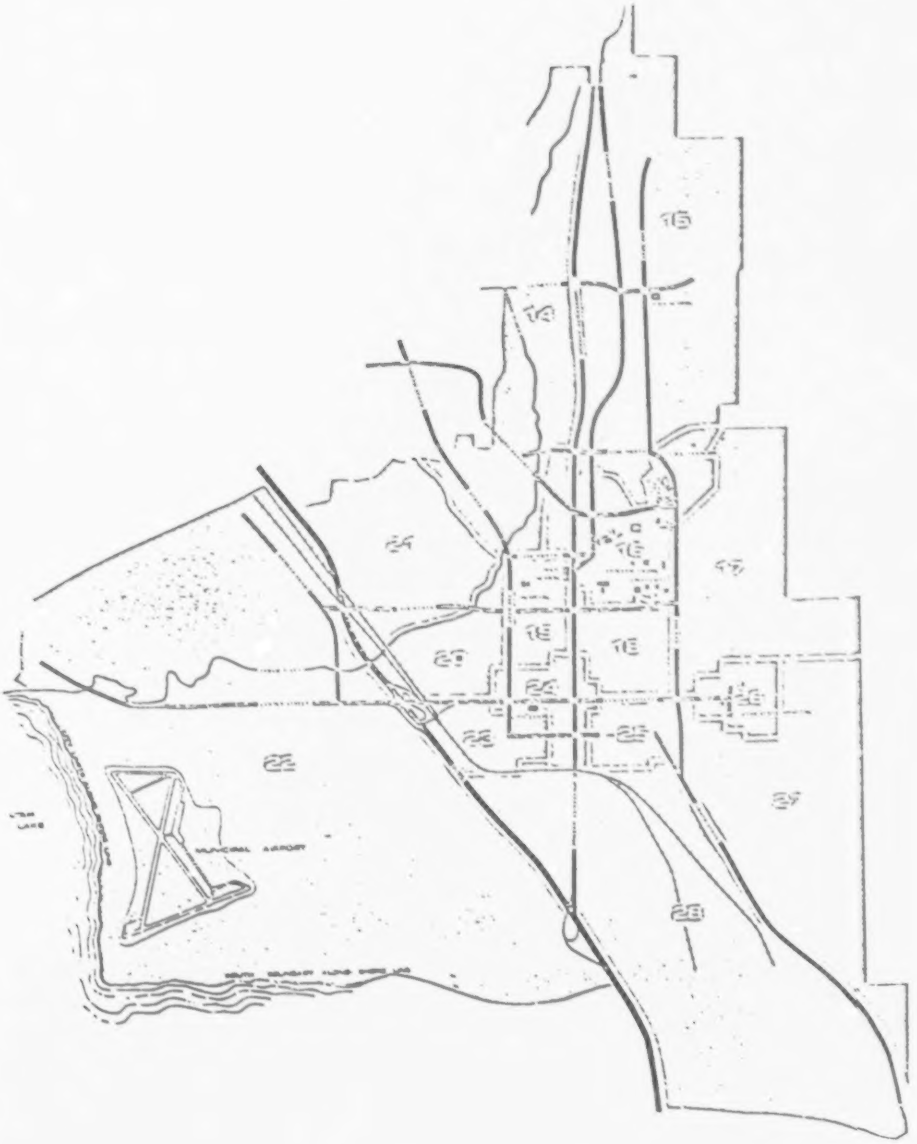
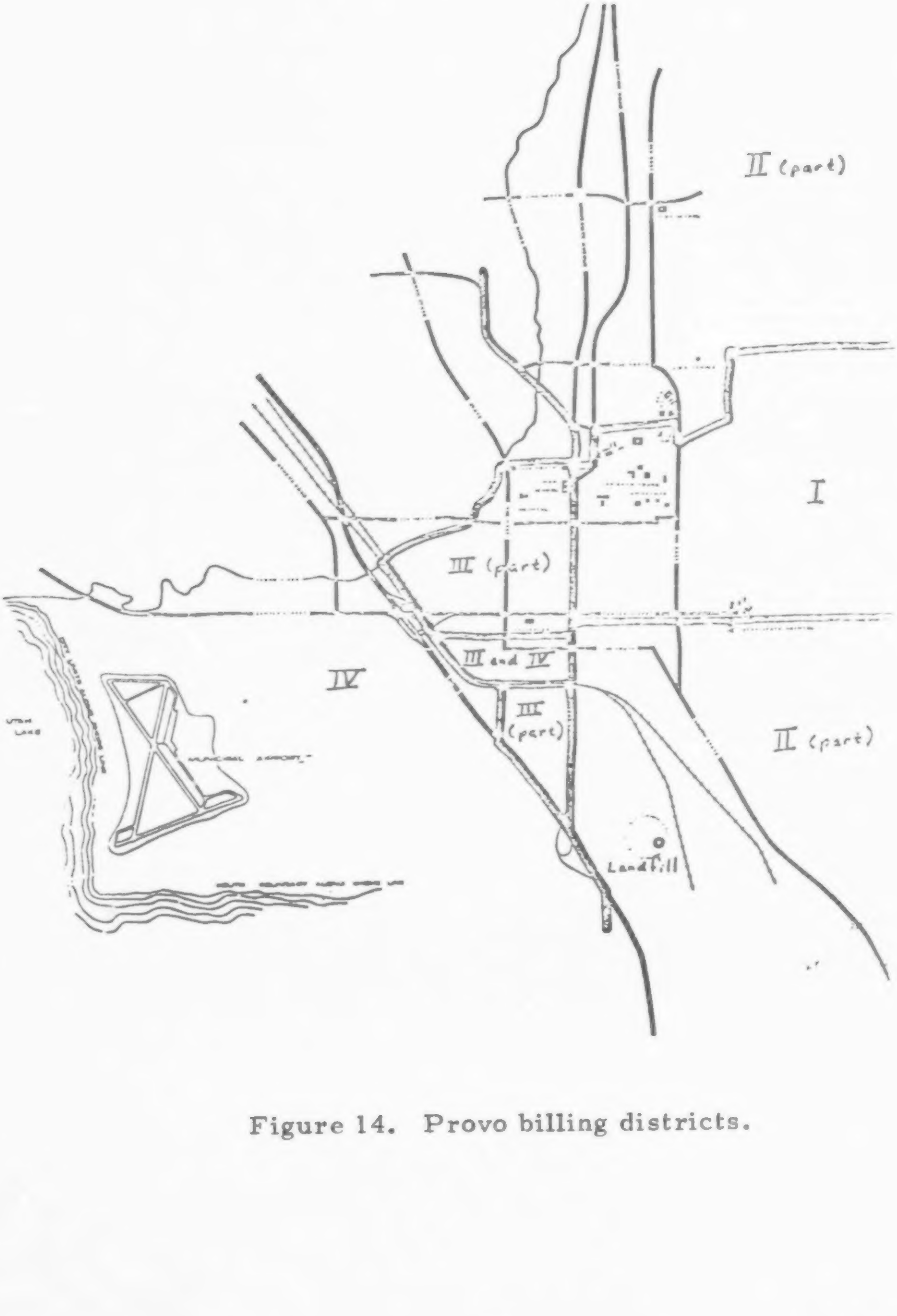

15
14
22
28
Utah Lake
Municipal Airport

Figure 13. Census tracts.



II (part)
I
III (part)
III and IV
IV
III (part)
II (part)
UTAH LAKE
MUNICIPAL AIRPORT
Landfill

Figure 14. Provo billing districts.

Table 18 shows user fee prices for residential service in recent years.

TABLE 18. PRICE OF RESIDENTIAL SERVICE, MONTHLY

Effective date	Curb service	Rear yard service
Feb. 1970	$1.25	$2.00
Sep. 1974	2.00	3.00
Jul. 1977	2.50	5.00

Source: Billing Department, Provo City Power Company.

EMPIRICAL RESULTS

In Section 4 above, a demand model for a service-based fee was presented. In that model, the amount of waste generated was seen to be affected by the price of the service through the effect of service levels on waste generation. Unfortunately, the lack of data in Provo makes it impossible to estimate the demand specifications presented in Section 4.

Other data that were available and that were given above provide an opportunity to indirectly test for an income effect in the demand for increased service levels. These data are the breakdown by billing tracts of the percentage of residents choosing backyard service. While these tracts do not correspond to Census Tracts, they can be identified in terms of "housing value" which might be taken as an (albeit imperfect) surrogate for income.

We specify, therefore, the following equation:

$$BY = a_0 \, P_{BY}^{\,a_1} + a_2 \, TRACT_1 + a_3 \, TRACT_2 + a_4 \, TRACT_3 \qquad (47)$$

where BY is the fraction of residents choosing backyard service, P_{BY} is the price of backyard service, and the $TRACT_i$'s are dummy variables representing the different areas of the city. There are 57 observations for each of the dates April 1977 and April 1978. These represent dates before and after the fee change.

Applying ordinary least squares to (47), we obtain (standard errors in parentheses):

$$BY = 5.14 + \underset{(.13)}{.13}\,P_{BY} + \underset{(8.3)}{2.7}\,TRACT_1 + \underset{(5.3)}{1.7}\,TRACT_2 + \underset{(2.5)}{.82}\,TRACT_3$$

$R^2 = .43$

$N = 114$

We see that each of the tracts, which are in declining order of housing value, are significantly and positively related to BY. Note, also, that both the magitude and significance of the estimated coefficients decline with TRACT number.

Conclusions

These findings in Provo lend some support to the existing evidence of positive income elasticities for solid waste services. However, because of the nature of the data, the support is not strong.

SECTION 8

GRAND RAPIDS, MICHIGAN

Grand Rapids, Michigan operates a non-mandatory solid waste collection service which participating households pay for by purchasing plastic bags or tag cards whose price includes payment for municipal collection and disposal. Specially marked city garbage bags are sold for \$2.30 per dozen; tags are sold for \$1.25 for 10. The city also sells special plastic trash cans whose contents are collected upon payment of an annual fee of \$4.35 or \$6.50, depending on the container size. In addition, several privately owned collection firms operate in Grand Rapids, and residential households may arrange service with these rather than pay for municipal service.

The metered-bag system is a hybrid[5] between the ideal quantity-based system discussed in Section 4 and the container-based system discused in Section 6. The empirical evidence from data collected provides little or no support for non-zero price elasticity.

This section describes the Grand Rapids solid waste system and the data collected, followed by a description of a model for the metered bag system and the results of testing hypotheses generated by the model. Finally, litter and administrative costs are analyzed and conclusions about the metered-bag system presented.

THE GRAND RAPIDS SOLID WASTE SYSTEM

Municipal collection of solid waste in Grand Rapids is done by one- or two-man crews on a once-weekly basis. Collectors take only refuse left at curbsides in city bags or with city collection tags attached. Waste is hauled to and disposed of at a sanitary landfill in Plainfield Township northeast of the city.

Municipal collection is under the authority of the Grand Rapids Environmental Protection Department, a department of city government; trucks and other equipment are leased from the city's motor pool. Because purchase of bags or tags by residents represents payment for collection, no billing or other administrative procedure dealing with households is required. In place of such procedures the Environmental Protection Department carries out distribution of bags and tags for retail sale.

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[5] Cf. pp. 96 below.

Origins of the Grand Rapids Fee System

Before 1970 most households in Grand Rapids dealt with two separate solid waste collection systems. Food wastes (garbage) were collected by the city's refuse department, and other solid wastes (trash) were collected by an assortment of large and small private hauling firms. A major impetus toward combined collection occurred when inexpensive plastic bags became available to households in shops. When the city allowed households to present garbage for collection in these rather than in cans, residents discovered it was a simple matter to slip trash in with garbage, thereby obviating demand for separate trash collection. In short, availability of plastic bag technology was bound to lead to combined collection, resulting in the city taking on a share of trash collection and/or private haulers taking an increased share of garbage collection.

In January 1970 the City Manager presented a plan to divide the city into ten collection districts which would be allocated between the city and private haulers on the basis of contract bids. Under this plan collection would have been financed through a monthly flat-rate user fee of $0.90 or $1.50 per household, depending on whether the fee would cover the added costs in the city budget or the full cost. The plan was strongly opposed by small private haulers who anticipated loss of business and who instigated a referendum in May of 1972 in which the plan was defeated by a margin of two to one. The city commission then instituted the bag system, which featured combined collection, but on a voluntary basis without an imposed user fee and hence without contracted collection districts.

The initial impact of the user fee bag system in 1972 was a re-allocation of households between the city and private haulers. There were about 65,000 households in Grand Rapids in the early 1970's. House counts early in 1972 showed that the city was collecting garbage (and an unknown quantity of trash) from 43,000 houses. The refuse department estimated that this figure would drop to 30,000 households presenting refuse for combined city collection when bags were introduced. Two months after the bag system was introduced the house count was 33,000 and private haulers reported an increase in business. It appears that the larger private haulers capable of combined collection benefited more than small haulers, many of whom ultimately went out of business. In 1970, 120 licensed private haulers were operating in Grand Rapids, only 25 of whom were equipped with trucks capable of hauling garbage or combined waste. A spot check of some 30 private haulers listed in the Grand Rapids telephone directory in 1978 indicated that the majority now deal only with commercial or industrial customers or else operate exclusively outside Grand Rapids.

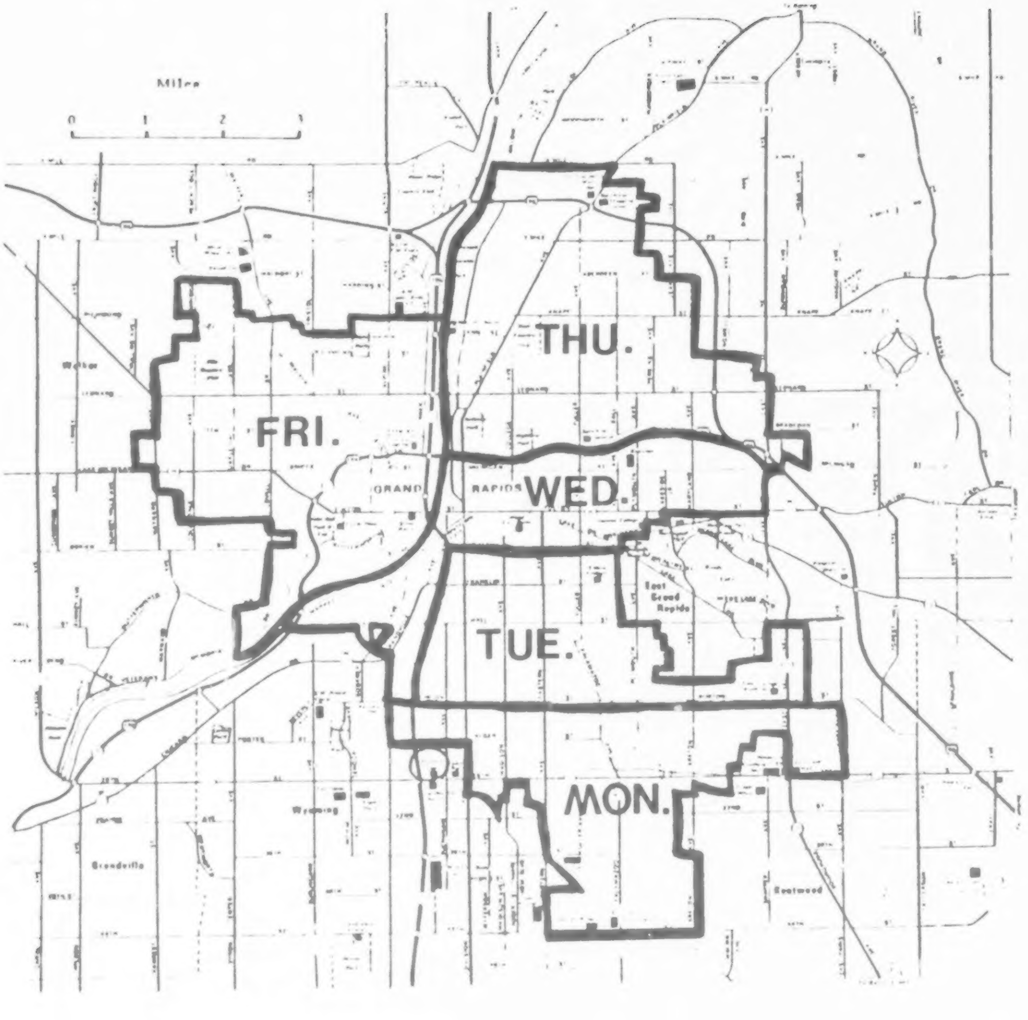
In February 1974 the "oil crisis" caused the supplier of Grand Rapids' bags to cut production because the manufacturing process relied on oil products suddenly in short supply. Responding on quite short notice, the Environmental Protection Department substituted a system of refuse tags for bags. These 3" x 6" tags could be attached to any refuse container to indicate payment for city collection. Within six months the city lost 21% of its previous customers, a shift attributed to the relative unpopularity of tags. This led to the re-introduction of bags in June 1975, by which time plastic bags were found to be no longer in short supply, although they were available only at a much higher price than before. No house counts have been conducted since that time, so it is difficult to know whether the combined availability of bags and tags had the desired effect of increasing the number of households choosing city collection.

Collection of Solid Waste in Grand Rapids

Grand Rapids is geographically divided into five collection districts from which household refuse is collected on the same day each week along 12 to 14 routes in each district. The location of collection districts is shown in Figure 15. The city maintains a fleet of 23 trucks, including nine rear-loading packers with a capacity of 25 cubic yards, six 31 cubic yard rear-loaders, and six 37 cubic yard side loaders. Two front loaders are used for collection from municipal buildings and a small number of public housing sites. All trucks are operated by two-man crews except the six Shupak side-loaders acquired in January of this year, which are operated by one-man crews and which are felt to have increased efficiency on routes where they are used.

Municipal collection is non-mandatory, and private haulers may operate in Grand Rapids so long as they comply with public health regulations and are licensed by the Environmental Protection Department. Industrial and commercial solid waste is not handled by the City. About 30 private haulers are listed in the Grand Rapids phone directory. It appears that most of these collect from commercial customers or else serve suburbs of Grand Rapids. Periodic surveys are made to determine the number of households choosing municipal collection as opposed to private collection or self-haul. The latest survey (July 1975) shows about 36,000 of the city's 65,000 households using city collection. The bag system has the advantage of not requiring records to be kept for each household. This also makes provision of back-yard service impractical because with no record of service requested collectors would have to enter every back yard to search for city bags. Private haulers usually offer back-yard service, and this appears to be the major reason why those opting out of city collection do so.

Residents may purchase refuse bags or tags in any of 80 retail outlets throughout the city including the city's 13 fire stations, 5 city government offices, and 65 commercial outlets such as supermarkets. City bags are made of thick plastic, have a 30 gallon capacity, and have a distinctive bright orange color with the city seal imprinted for identification. Refuse for collection must be left, properly bagged, on curbsides no earlier than 7.00 p.m. on the evening before the scheduled collection day. Only refuse in city bags or with city tags attached is collected. At present about 40% of refuse collected is in city bags, 60% is left with tags. During the fall 50-gallon city leaf bags and city leaf tags are also sold for $0.10 and $0.05, respectively, which may be used only for leaves and yard waste.


Miles
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THU.
FRI.
GRAND
RAPIDS
WED.
East Grand Rapids
TUE.
MON.
Walker
Wyoming
Grandville
Kentwood

Figure 15. Grand Rapids collection districts.

Disposal of Solid Waste in Grand Rapids

Residential solid waste in Grand Rapids is hauled to a sanitary landfill owned and operated by Kent County in Plainfield Township northeast of the city (see map in Figure 16). Prior to 1970 the city operated landfills within its boundaries. Increased quantities of refuse and lack of open space eventually made this unfeasible. To a large extent the suburban towns adjacent to Grand Rapids have faced the same problem; the result has been increased cooperation on the regional level to develop a disposal system operated by Kent County.

In 1970 Grand Rapids entered into an agreement with Kent County whereby the city agreed to make exclusive use of county landfills for waste disposal. The current Plainfield site has been in use since 1977, and is expected to reach capacity in 1985. The city pays $6.16 per tonne for use of the landfill.

Administration of the Grand Rapids Solid Waste System

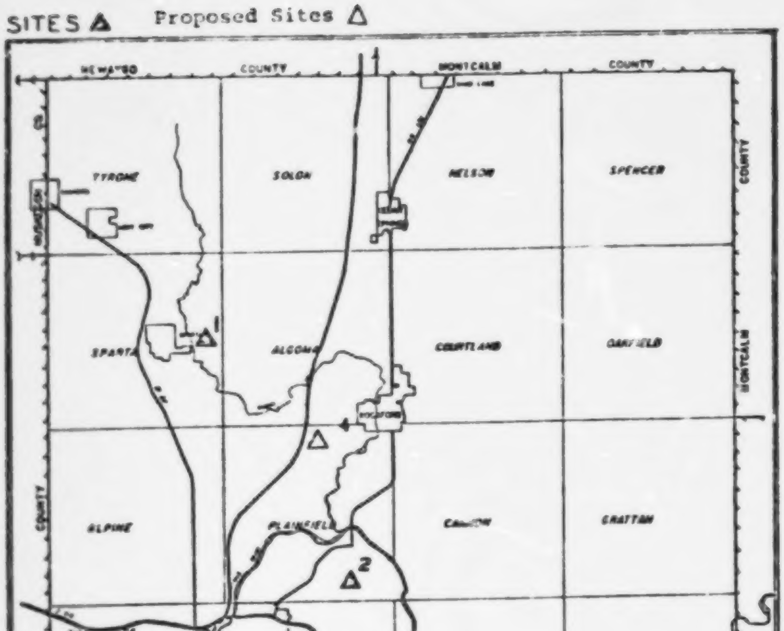
Perhaps the biggest administrative change brought about by the bag system has been the tendancy to become involved in marketing. The system has two distinct advantages over other types of user fee systems that are immediately apparent: there are no administrative costs associated with billing or keeping track of the level of service to each customer; and marketing activity provides a direct public relations link between the Department of Environment Protection and the public. The latter is difficult to quantify, but Department officials speak highly of this aspect of the system. Bags were initially distributed through the city's 13 fire stations and two downtown municipal office locations. The distribution network was later expanded to include commercial outlets, retailers being given four percent of the revenue for bags sold to cover purported handling costs.

Besides the Refuse Collection Division, the Environmental Protection Department has divisions dealing with waste water treatment, air pollution contol, and sewer maintenance. Refuse collection is administered autonomously through an enterprise fund financed out of revenues from sale of bags and tags and a transfer from general funds. Revenue from sales covers about half of costs (see Table 25 below). Disposal operations are under the jurisdiction of the county. The Department director reports to the City Manager, who in turn reports to the City Commission consisting of the mayor and six council members.

DATA COLLECTED

Data on Quantities Disposed

The Kent County Department of Public Works records quantities of waste delivered to landfills which it operates and bills its customers, including the Grand Rapids EPD, monthly. Quantities hauled by municipal trucks serving residential routes were available for the period from August


SITES ▲
Proposed Sites △
NEWAYGO
COUNTY
MONTCALM
COUNTY
TYRONE
SOLON
NELSON
SPENCER
SPARTA
ALGOMA
COURTLAND
OAKFIELD
ALPINE
PLAINFIELD
CANNON
GRATTAN
CITY OF GRAND RAPIDS
ADA
VERGENNES
WALKER
EAST GRAND RAPIDS
CITY OF LOWELL
CITY OF GRANDVILLE
PARIS
CASCADE
LOWELL
WYOMING
BYRON
GAINES
CALEDONIA
BOWNE
ALLEGAN
COUNTY
BARRY
COUNTY
OTTAWA
COUNTY
MONTCALM
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COUNTY
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KENT COUNTY PLANNING DEPARTMENT

Figure 16. Location of waste disposal sites.

1972 to February 1978. These quantities are listed in Table 19 and illustrated in Figure 17. Quantities billed to the Grand Rapids Parks Department, which we used as a proxy for rate of litter, are listed for most months in Table 19 as well. Because several different disposal sites with different measurement methods were in use during this period, some quantities were recorded in short tons and some in cubic yards. A conversion factor of 0.29 tons per cubic yard (or 0.344 tonnes per cubic meter) was used to compute total tonnage of municipally collected residential and parks waste. The location of county disposal sites is shown in Figure 16.

Grand Rapids residents may dispose of self-hauled residential waste at county landfills for a charge of $3.50 per carload or truckload. Quantities of self-hauled residential waste originating in Grand Rapids are not separately available from other cash transactions, however. Quantities collected by private haulers and delivered to county landfills were available, but it was impossible to know what proportion of total privately-hauled waste this represented or what proportion of this total originated from Grand Rapids households without examining records of private haulers and landfill operators.

Quantity of residential waste collected appears to show some seasonal variation. Quantities are greater from April, when the snow cover melts, though October, when leaves are collected, and about 20% less from November to March. Apart from seasonal variation, quantities have remained fairly constant over the five-year period with two exceptions: A three-week strike by sanitation workers in July 1974 reduced quantity collected for that month, and quantities reported before March 1973 appear to be suspiciously low. Neither the 1976 price change nor the transitions between bags and tags in 1974 and 1975 appear at first glance to have had an effect on quantity collected.

Data on Collection

In addition to quantity of waste collected, Table 19 shows quantities of metered bags and tags sold by the Refuse Department and an estimate of weight per bag. The latter is illustrated in Figure 18. Figures for number of bags sold are derived from revenue records similar to those in Table 20, which shows how revenue from tag sales were distributed during the last six months of 1974. Note that 63% of tags sold (providing 62% of revenue) are distributed through retail outlets. Because these figures represent wholesale sales, they are a poor approximation to numbers of bags left for collection in any given month. Much of the variation displayed in Figure 18 may therefore be due to stocking policies by retailers. For example, an especially large number of bags and tags were sold in June 1976, immediately before the price change took effect, and an especially small number were sold in July 1976 as stocks were depleted. Presumably, merchants and/or households were stocking up at old prices.

TABLE 19. QUANTITIES OF WASTE COLLECTED AND CONTAINERS SOLD

Date	Tonnes collected	Cu. m. collected	Total collected	Bags sold	Tags sold	Kgs. / bags	Parks waste
Aug. 72	712	0	712	591,088	0	1.2	NA
Sep. 72	427	0	427	114,352	0	3.7	NA
Oct. 72	515	0	515	298,328	0	1.8	NA
Nov. 72	774	0	774	311,488	0	2.5	NA
Dec. 72	470	0	470	244,345	0	1.9	NA
Jan. 73	378	0	378	306,600	0	1.2	NA
Feb. 73	545	0	545	961,187	0	5.7	NA
Mar. 73	2,608	0	2,608	263,842	0	9.9	NA
Apr. 73	3,014	233	3,093	288,202	0	10.8	NA
May 73	2,331	1,141	2,723	363,059	0	7.5	NA
Jun. 73	1,826	767	2,106	333,448	0	6.3	NA
Jul. 73	2,048	3,026	3,089	47,830	0	64.6	NA
Aug. 73	2,329	4,165	3,762	266,555	0	14.1	NA
Sep. 73	1,807	3,493	3,009	266,028	0	11.3	NA
Oct. 73	2,257	4,632	3,851	359,310	0	10.7	NA
Nov. 73	1,989	4,122	3,407	379,310	0	9.0	NA
Dec. 73	1,357	3,243	2,473	267,037	0	9.3	NA
Jan. 74	1,908	2,612	2,807	NA	0	NA	NA
Feb. 74	1,240	2,541	2,115	226,051	0	9.3	NA
Mar. 74	1,435	2,950	2,450	314,086	0	7.8	NA
Apr. 74	1,849	3,360	3,006	0	126,970	23.7	3.96
May 74	2,571	4,293	4,048	0	14,250	284.1	7.94
Jun. 74	1,994	3,453	3,182	0	NA	NA	6.43
Jul. 74	805	891	1,111	0	132,190	8.4	7.03
Aug. 74	2,053	4,749	3,687	0	221,846	16.6	9.33
Sep. 74	1,500	2,934	2,510	0	267,784	9.4	4.81
Oct. 74	2,065	3,548	3,286	0	274,484	12.0	0.99
Nov. 74	1,503	2,336	2,307	0	186,556	12.4	0.20
Dec. 74	1,107	2,669	2,025	0	251,946	8.0	NA
Jan. 75	1,685	2,934	2,694	0	246,418	10.9	NA
Feb. 75	1,152	2,190	1,906	0	232,602	8.2	NA
Mar. 75	1,289	2,452	2,133	0	155,658	13.7	1.49
Apr. 75	2,216	2,971	3,239	0	236,910	13.7	5.53
May 75	2,269	3,067	3,324	0	263,064	12.7	9.04

(continued)

TABLE 19 (continued)

Date	Tonnes collected	Cu. m. collected	Total collected	Bags sold	Tags sold	Kgs. / bag	Parks waste
Jun. 75	2,035	2,567	2,938	4,308	337,690	8.6	20.09
Jul. 75	2,170	3,499	3,374	33,089	121,438	21.9	30.50
Aug. 75	1,861	2,994	2,891	102,168	232,346	8.7	12.51
Sep. 75	1,735	2,889	2,729	56,668	190,364	11.1	6.11
Oct. 75	2,049	3,996	3,425	93,296	111,330	16.7	3.47
Nov. 75	1,220	1,905	1,876	113,056	220,032	5.6	0.73
Dec. 75	1,623	3,136	2,703	109,781	124,108	11.6	NA
Jan. 76	1,338	2,097	2,054	99,845	175,638	7.4	NA
Feb. 76	1,289	2,454	2,134	NA	NA	NA	1.57
Mar. 76	1,851	3,939	3,206	92,297	136,086	14.0	6.34
Apr. 76	1,847	3,801	3,155	115,512	154,160	11.7	17.83
May 76	1,779	3,284	2,909	NA	NA	NA	44.03
Jun. 76	0	9,296	3,199	264,931	377,666	5.0	95.42
Jul. 76	0	8,389	2,887	35,463	68,632	27.7	242.67
Aug. 76	0	8,314	2,860	108,913	187,176	9.7	311.07
Sep. 76	0	9,984	3,436	91,268	151,264	14.2	253.29
Oct. 76	0	7,396	2,545	107,101	123,776	11.0	88.99
Nov. 76	0	7,342	2,528	114,347	190,640	8.3	39.46
Dec. 76	0	8,304	2,858	96,147	152,832	11.5	35.83
Jan. 77	0	6,683	2,300	96,303	114,216	10.9	14.70
Feb. 77	0	6,769	2,329	11,500	168,148	8.3	21.23
Mar. 77	0	10,500	3,613	94,031	179,840	13.2	88.36
Apr. 77	0	9,821	3,397	113,064	173,608	11.8	79.38
May 77	0	10,000	3,441	134,513	202,984	10.2	67.03
Jun. 77	3,656	405	3,796	207,252	344,752	6.9	41.59
Jul. 77	3,012	0	3,012	34,945	53,762	34.0	26.98
Aug. 77	3,799	0	3,799	44,270	79,352	30.8	27.71
Sep. 77	2,996	0	2,996	206,147	328,504	5.6	13.75
Oct. 77	2,928	0	2,928	122,555	212,976	8.7	3.87
Nov. 77	3,596	0	3,596	135,287	203,728	10.6	1.68
Dec. 77	2,194	0	2,194	113,890	149,088	8.3	2.70
Jan. 78	1,831	0	1,831	106,248	139,304	7.4	1.35
Feb. 78	1,960	0	1,960	110,760	168,360	7.0	1.11

Sources: Kent County Department of Public Works, Grand Rapids Environmental Protection Department.

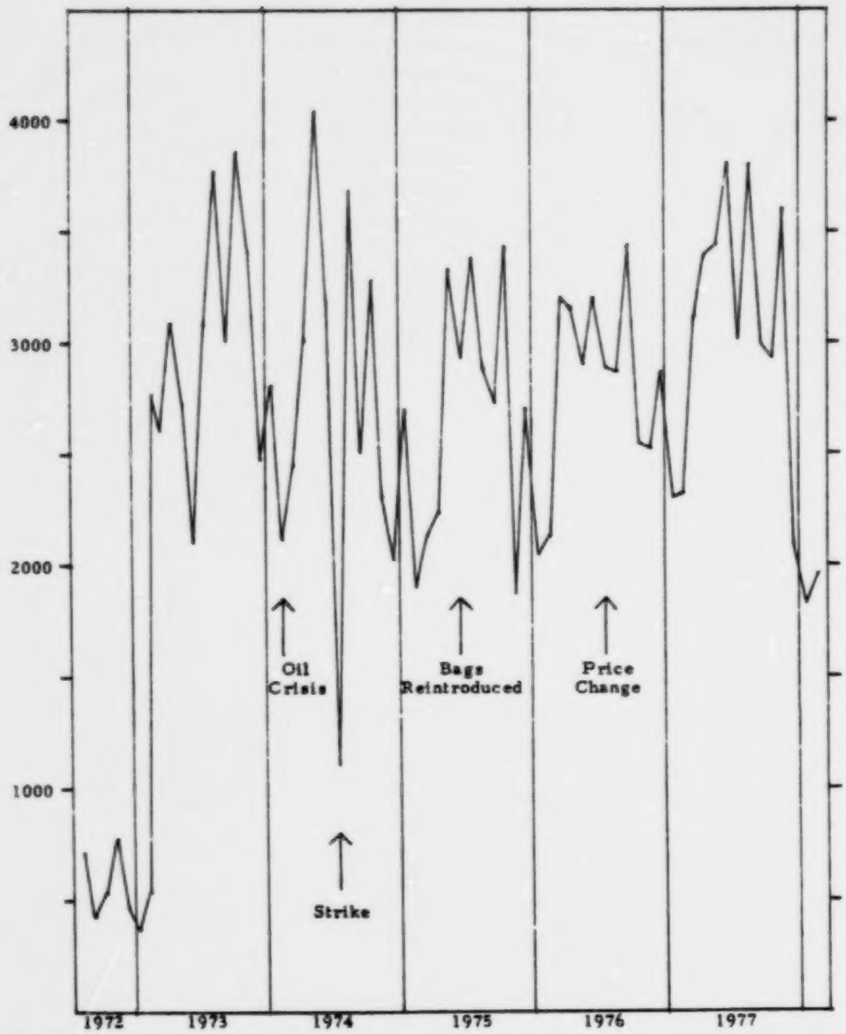


Figure 17. Tonnes of solid waste collected, Grand Rapids.

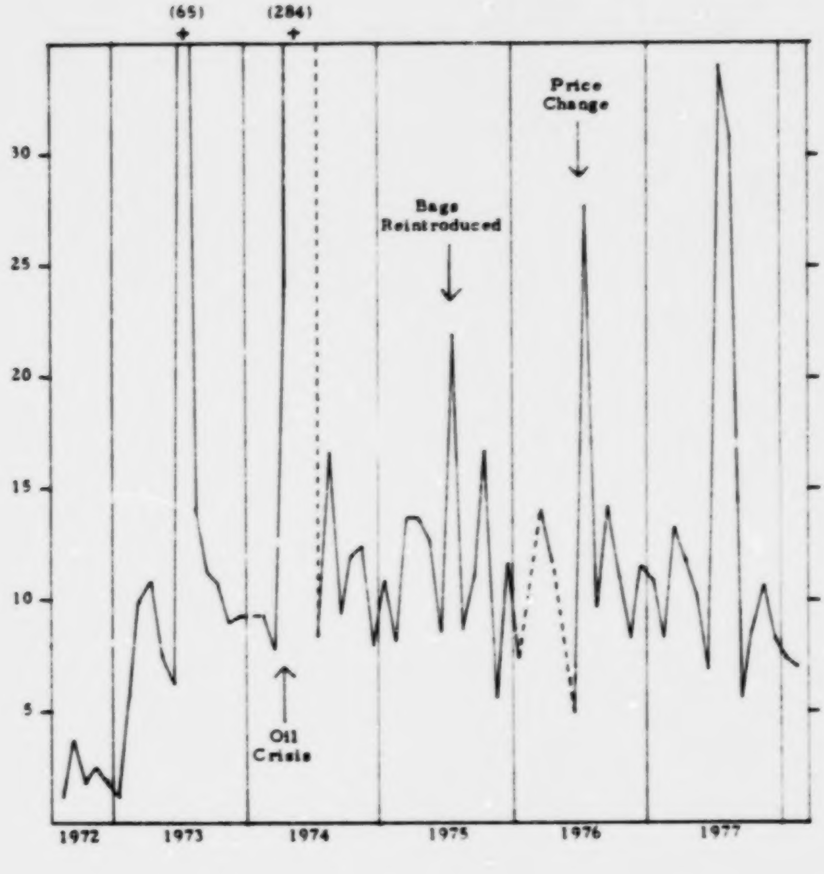


Figure 18. Kilograms of waste collected per bag (or tag) sold.

TABLE 20. CITY REFUSE TAG SALES, 1974

MONTH	FIRE STATIONS	RETAIL SALES	CITY HALL	COMPLEXES	TOTAL
July	4,198	7,776	592	329	12,895
August	7,582	12,806	804	459	21,651
September	9,755	14,938	951	512	26,156
October	6,850	18,298	862	676	26,686
November	6,954	10,310	571	391	18,226
December	7,657	15,494	819	579	24,549
January	6,542	16,426	935	590	24,493
	49,538	96,048	5,534	3,536	134,656
% of Sales	32.03	62.10	3.58	2.29	

TOTAL August - January = 141,761
AVG. MONTH August - January = 23,627

ESTIMATED February - June = 118,344

ESTIMATED FY 75 Revenues = 273,000

FY 75 REVENUES BY LOCATION

Fire Stations: 87,442
Retail Sales : 169,533
City Hall : 9,773
Complexes : 6,252
273,000

FY 75 REVENUE PROJECTION-From Sale of Tags.......... 404,000

FY 75 REVISED PROJECTION-From Data Listed Above..... 273,000

Difference..... 131,000

Percent Difference..... 32.43%

Source: Grand Rapids Environmental Protection Department.

During the first few years after introduction of the metered bag system, the Refuse Division periodically conducted counts of the number of residences where bags were left for municipal collection. The results of these surveys are shown in Table 21. These figures are probably somewhat less than the number of households receiving municipal service, since households which generate less than a full bag of waste per week and which are willing to leave refuse on their premises an extra week will not set out a bag for collection every time, and since households on vacation are not counted. The number of households receiving municipal collection appears to have been decreasing, but there is a great deal of variation in these figures, and the Refuse Division estimates that there has been an increase in the number of households using municipal collection since 1975 due to the availability of both bags and tags and to the increased number of retail outlets. They estimate that refuse is currently collected from between 33,000 and 37,000 residences.

TABLE 21. HOUSEHOLDS RECEIVING CITY COLLECTION

Date (week)	Number	Date (week)	Number
28 Aug. 72	33,072	20 Aug. 74	34,151
27 Nov. 72	34,388	16 Dec. 74	24,861
19 Mar. 73	34,183	6 Jan. 75	32,473
18 Jun. 73	36,090	17 Feb. 75	24,358
25 Feb. 74	34,700	24 Feb. 75	25,070
20 May 74	35,314	3 Mar. 75	29,135

Source: Grand Rapids Environmental Protection Department.

Indirect support for the view that providing customers a choice between bags and tags increased the number of households using municipal collection may be inferred from Figure 19, which illustrates the relative percentages of sales of bags and tags, together with figures from Table 19. Re-introduction of bags in 1975 resulted in an overall increase in sales from about 230,000 tags to about 300,000 bags and tags together. Most of the increase came in the first three or four months as new customers were attracted by availability of bags. After this initial period of adjustment a pattern was established of about 40% of customers buying bags and 60% buying tags. Note that although the price change increased the price of tags relative to bags (cf. Table 26), there does not appear to have been a shift to bag use as a result.

Finally, information on household income was taken from data on personal income tax collected quarterly in Grand Rapids. These data are shown in Table 22.

TABLE 22. INCOME TAX COLLECTED

1972-3	$1,604,659	1975-1	$2,484,686
1972-4	1,926,198	1975-2	2,936,075
1973-1	2,161,064	1975-3	2,059,131
1973-2	2,825,324	1975-4	2,068,592
1973-3	2,105,873	1976-1	2,707,630
1973-4	1,834,541	1976-2	2,232,262
1974-1	2,276,754	1976-3	2,419,450
1974-2	2,860,191	1976-4	2,327,898
1974-3	2,191,150	1977-1	2,899,118
1974-4	2,000,372	1977-2	3,522,284

Source: City of Grand Rapids.

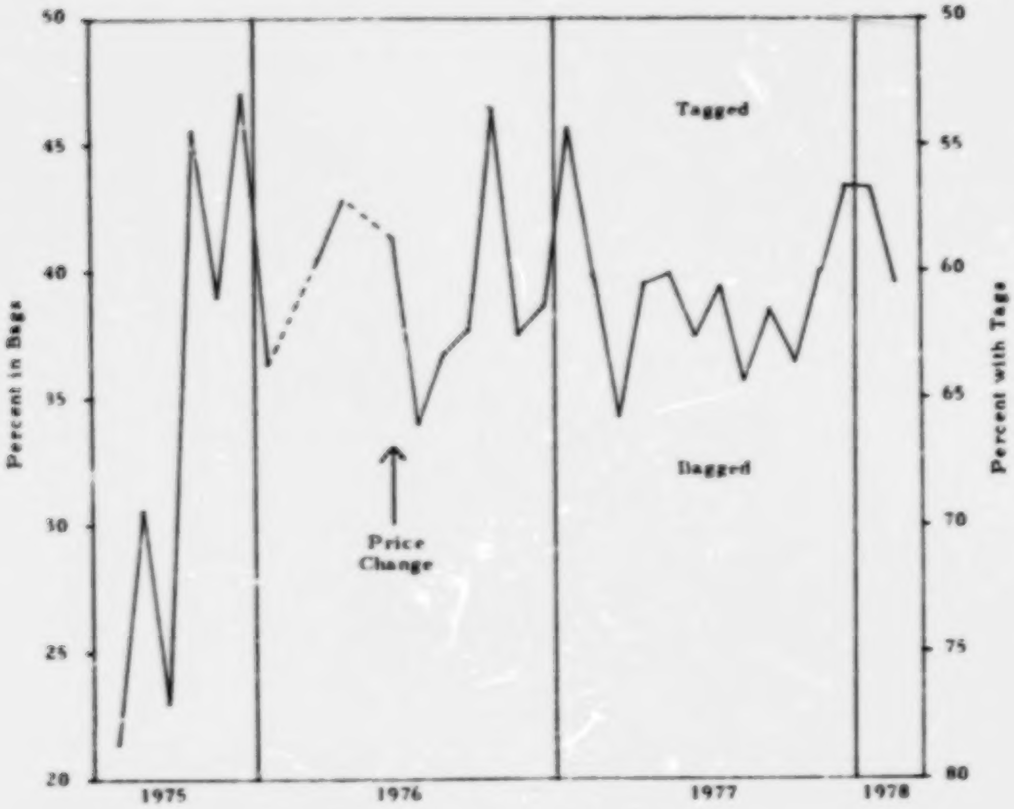


Figure 19. Relative popularity of bags and tags.

Data on Administration

Computerized cost accounting procedures were introduced in Grand Rapids in July 1976. This system produces monthly statements listing quantity of waste hauled and various cost components for each collection vehicle. A summary of data from these statements is given in Table 23. Quantities are presented here in metric tonnes; the original data were in cubic yards from July 1976 to May 1977 and in short tons thereafter. Total direct costs are total costs less overhead costs. Average and marginal costs of collection were estimated monthly from these figures as shown in Table 23; derivation of these figures is discussed below.

During the period for which cost data are available, three changes occurred which might be expected to affect collection costs significantly. In June 1977 collected waste began to be hauled to the Ten-Mile Disposal Site (site no. 2 in Figure 16) instead of to the Sparta Disposal Site (site no. 1 in Figure 16). The Ten-Mile site is somewhat closer, but comparative figures on haul time, access, and dumping time are not available. In July 1977 collectors received a six percent wage increase, as shown in Table 24. And in February 1978 six new side-loading vehicles were added to the fleet of collection trucks. Average and marginal costs per ton both appear to be rising over time, but there is considerable variation, and insufficient data is available to attribute this increase to one particular factor. The fact that figures for tonnes collected do not match figures in Table 19 indicates a combination of measurement error and the fact that some landfill hauls billed to the Refuse Division were for special collections not included in the computer reports.

We noted earlier that revenues from sales of bags and tags has never been adequate to cover operating expenditures of the Refuse Division. The relation of these two items is shown in Table 25 for the past five years. In this table figures are taken from annual budgets. Table 26, taken from various historical sources, shows the retail price of bags and tags and the cost to the city for these items.

Finally, Table 27 presents an historical summary of changes in household collection. Population estimates are based on Bureau of Census data for Grand Rapids. In 1970 the city had 63,507 occupied housing units, including 58,987 (86.6%) in structures of one, two, or three units. On the assumption that the ratio of each of these figures to population has remained constant, an estimate was made of the number of households eligible for municipal collection. Estimates for number of households receiving collection were available for the years 1972 to 1975. For 1976 and 1977, high and low estimates are shown, based, respectively, on a projection of the trend for the first four years and on the Refuse Division estimate of around 35,000. Bearing in mind the high level of uncertainty in many of these figures, most of the subsequently derived figures seem stable. Note that when the Refuse Division estimate for number of households since 1975 is used, results are more in line with those before that year, lending further credibility to this higher estimate.

TABLE 23. COST OF COLLECTION, GRAND RAPIDS

Date	Tonnes collected	Number of trucks	Tonnes per truck	Total direct cost	Direct cost per tonne	Estimated marginal cost	R^2 of estimation
Jul 76	2,904	14	207	$40,816	$14.06	$12.63	.70
Aug 76	2,817	15	188	45,312	16.09	13.06	.88
Sep 76	2,423	14	173	41.138	16.98	17.11	.89
Oct 76	2,860	15	191	52,132	18.23	18.84	.98
Nov 76	2,388	15	159	42,663	17.87	17.93	.76
Dec 76	2,151	14	154	42,749	19.87	18.62	.80
Jan 77	2,105	14	150	46,770	22.22	21.41	.98
Feb 77	2,083	14	149	41,202	19.78	21.73	.86
Mar 77	2,878	14	206	50,668	17.61	18.30	.60
Jun 77	3,198	16	200	57,231	17.90	12.26	.64
Jul 77	2,947	16	184	62,132	21.08	18.47	.81
Aug 77	3,064	16	192	67,645	22.08	13.72	.43
Sep 77	3,120	18	173	64,560	20.69	16.83	.86
Oct 77	3,074	16	192	60.092	19.55	14.29	.84
Nov 77	3,103	16	194	61,123	19.70	11.59	.79
Dec 77	1,951	15	130	51,382	26.34	16.17	.80
Feb 78	2,109	19	111	63,651	30.18	26.48	.94
Average 1/	2,692	15	178	51,726	19.22	16.44	

1/ Average excluding February 1978.

Sources: Kent County Department of Public Works, Grand Rapids Environmental Protection Department.

TABLE 24. BASE ANNUAL WAGE OF COLLECTION EMPLOYEES

Year	FY 75	FY 76	FY 77	FY 78
Sanitary worker	$9,060	$ 9,610	$10,400	$11,024
Refuse packer operator		10,400	11,190	11,856
Equipment operator I	9,503	10,005	10,795	11,440

(Fiscal year extends from 1 July to 30 June.)

Source: Grand Rapids Environmental Protection Department.

TABLE 25. RELATION OF OPERATING COSTS TO SALES REVENUES

	Total operating expenditure	Revenue bags and tags	% of expenditure covered by bag and tag sales
1973	$ 978,811	$507,081	52.8%
1974	829,385	437,514	52.8%
1975	817,356	290,575	35.5%
1976	969,295	441,360	45.5%
1977	1,117,527	507,354	45.4%

Source: Grand Rapids Environmental Protection Department.

TABLE 26. PRICE OF BAGS TO HOUSEHOLDS AND COST TO CITY

Effective date	Price of bags	Price of tags	Cost of bags	Cost of tags
Jun. 1972	$.125	$ -	$.0248	$ -
Mar. 1974	-	.10	-	.0049
Jan. 1975	-	.10	-	.0038
Jun. 1975	.167	.10	.0536	.0038
Jun. 1976	.192	.125	.0536	.0038
Mar. 1977	.192	.125	.0598	.0038

Source: Grand Rapids Environmental Protection Department.

TABLE 27. ANNUAL COST AND COLLECTION FIGURES

Year	1972	1973	1974	1975	1976	1977 1/	76-77 2/
Population, July 1 (est.) 3/	193,400	191,500	189,700	188,000	186,200	184,500	
Eligible households	55,000	54,400	54,000	53,400	53,000	52,500	
Households with city collection	33,700	35,100	32,300	27,800	27,200	25.200	35,000
% of eligible with city collection	61.3	64.5	59.8	51.9	51.2	47.8	66.9
Tonnes disposed		31,044	32,534	33,232	33,771	37,401	
Bags/tags distributed		4,102,408	2,419,396	2,984,326	3,412,433	3,524,715	
Kgs./bag		7.57	13.45	11.14	9.90	10.61	
Bags/household/week		2.25	1.44	2.07	2.42	2.69	1.91
Kgs./household/week		16.99	19.40	16.09	23.91	28.51	19.55
Revenue from user charge		$507,081	$437,514	$290,575	$441,360	$507,354	
Revenue/tonne		16.33	13.45	8.74	13.07	13.57	
Revenue/household/month		1.20	1.13	0.87	1.35	1.68	1.13
Total operating expenditure		978,811	829,385	817,356	969,295	1,117,527	
Expenditure/tonne		31.53	25.49	24.60	28.70	29.88	
Expenditure/household/month		2.32	2.14	2.45	2.97	3.69	2.48

1/ Low estimate of households receiving collection.

2/ High estimate of households receiving collection.

3/ Current Population Reports, U.S. Department of Commerce, Bureau of the Census.

EMPIRICAL RESULTS

A metered-bag system might be expected to effect residential solid waste behavior in two ways that are different from container-based systems. First, the capacity of the bag is generally less than that of a waste can. Therefore, a metered-bag system faces the resident with a smaller increment of waste allowed between addition of a new bag. Second, because the bag is consumed when filled, the resident faces a direct charge for each additional bag used. With a container-based system, once the number of containers is selected, there is no direct charge to the customer for using the number of cans chosen. Thus, the metered bag appears to fall in between the "ideal" system outlined in Section 4 above and a container-based system such as that in Sacramento.

This hybrid nature of the metered-bag system makes the modeling of consumer demand for waste collection services somewhat more tricky than that of the container-based system. Fortunately, it turns out that it is possible with a single equation model to estimate the effect of price on waste generation regardless of whether the bag system is considered to be more like the "ideal" system with a charge varying with weight or more like the container system with the unit of capacity being the bag rather than the can.

The Model

Recall that with an ideal system, the resident is charged for the weight presented for collection each collection period. If the metered-bag system were a reasonably good aproximation of the ideal system, the resident would not be able to "hide" additional waste by filling each bag with more waste. Therefore, the ratio of bags to waste would be constant and the "price per pound" would be calculated as:

$$p = p_{BAG} \Big/ (q/BAGS) \tag{48}$$

where p is the price per pound, p_{BAG} is the price per bag, q is the weight of the waste presented for collection, and BAGS is the number of bags used.

If a double log specification is assumed for the waste generation function, it will look like:

$$q = a_0 \, p^{a_1} \, y^{a_2} \, s^{a_3} \tag{49}$$

where s represents seasonal factors, y is income, and q and p are as before. Substituting (48) into (49) gives:

$$q = a_0 P_{BAG}^{a_1} (q/BAGS)^{-a_1} y^{a_2} s^{a_3} \tag{50}$$

If the assumption concerning the constancy of the waste to bags ratio is correct, we can rewrite (50) as:

$$q = a_0{}' P_{BAG}^{a_1} y^{a_2} s^{a_3} \tag{51}$$

where: $a_0{}' = a_0 (q/BAGS)^{-a_1}$

Thus, we needn't make use of the data we have on the number of bags sold in Grand Rapids. This is fortunate since, as we noted above, the data is on wholesale sales and, therefore, incorporates inventory phenomena not on the part of the household but on the part of the retail outlets.

Suppose that instead of being viewed as an ideal system, the metered-bag system were merely another capacity-based system with a different representation of capacity. Then, from the discussion in Section 4 above, the theoretical representation of the demand model would be (assuming again a double-log specification):

$$q = b_0 \, BAGS^{b_1} y^{b_2} s^{b_3} \tag{52}$$

$$BAGS = c_0 P_{BAG}^{c_1} y^{c_2} q^{c_3} \tag{53}$$

where the variables are defined as above. Substituting (53) into (52) and simplifying gives:

$$q = b_0{}' P_{BAG}^{b_1{}'} y^{b_2{}'} s^{b_3{}'} \tag{54}$$

Note that the specification in (54) is the same as that in (51). Therefore, estimation of either equation provides information about both possibilities. The difference is that if the metered-bag system is actually a capacity-based system, then the coefficients estimated for (54) no longer represent elasticities of price and income. Assuming some reasonable restrictions on the elasticities in (52) and (53), however, will allow us to determine the sign on the price and income terms if the actual elasticities are to be negative and positive respectively.

For example, if it is assumed that:

$$0 > b_1 > -1, \quad 1 + a_1 (1 + b_3) > 0, \quad |a_1 b_2| < a_2$$

then the signs on b_1 and b_2 would be as expected from economic theory. Note, however, that the numerical estimates of b_1 and b_2 in (54) cannot be construed as elasticities since they are complicated functions of other parameters and are not identifiable.

Estimation

In order to estimate Equation (51) (or, equivalently, Equation (54)), we must first transform it into the linear form:

$$\ln(q) = \ln(b_0') + b_1' \ln(p_{BAG}) + b_2' \ln(y) + b_3' s \tag{55}$$

The next step is to identify the actual data series used in the estimation. For total waste disposed, the series presented above was employed. Because some of the data is expressed in cubic yards and some in tons, it was necessary to make the two comparable. To do this, we used the formula:

TONS = 0.29 YARDS

The factor of .29 is based on experience from Grand Rapids. For the "price of bags," we use the price of a bag. For the period during which bags were not available and tags were used, we use the implicit price of a bag based on the price of a tag. That is, we see from Table 26 above that when tags were $0.10, bags were $0.167. Therefore, when bags were not available but tags were and they cost $0.10, we use .167 as the price of a bag. Therefore, the series on the price of bags that was used is reproduced in Table 26.

For income, a better substitute was available in Grand Rapids than in any of the other cities. Grand Rapids has a city income tax whose rate has not changed over the period estimated. Therefore, we use quarterly observations on income tax collections as the surrogate for personal income with the quarterly observation being used in all three months.

For the seasonal variable, we use a dummy variable for Spring. This dummy serves two purposes. First, as is evident from Table 19 above, there is a high generation point in the months of May and June. Second, personal income tax collections peak in April with the filing of returns. Both of these factors are held constant by the use of the Spring dummy.

Applying ordinary least squares to (55) gives the following result (standard errors in parentheses):

$$\ln(q) = 7.1 - \underset{(.46)}{.33} \ln(p_{BAG}) + \underset{(.25)}{.02} \ln(y) + \underset{(.10)}{.14} SPR \qquad (56)$$

$$R^2 = .08$$

$$N = 50$$

As we can see, the coefficients on price and income have the expected signs but are insignificantly different from zero.

It is unlikely, however, that the effect of price or income changes are felt immediately. If a distributed lag model is specified and estimated the results are (standard errors in parentheses):

$$\ln(q) = 5.4 - \underset{(.89)}{1.2} \ln(p_{BAG}) + \underset{(1.12)}{.50} \ln(p_{BAG})_{-1} + .29 \ln(p_{BAG})_{-2}$$

$$- \underset{(.37)}{.0009} \ln(y) - \underset{(.42)}{.43} \ln(y)_{-1} + \underset{(.31)}{.70} \ln(y)_{-2} + \underset{(.11)}{.23} SPR$$

$$R^2 = .20$$

$$N = 46$$

None of the coefficients on price are significant and only the second lagged income term is significant (and of the proper sign).

The positive price elasticities are somewhat troubling even though they are insignificant. Therefore, we next specified and estimated the model (standard errors in parentheses):

$$\ln(q) = 4.4 - \underset{(.49)}{.50} \ln(p_{BAG}) + \underset{(.21)}{.40} \ln(y)_{-2} + \underset{(.09)}{.17} SPR$$

$$R^2 = .15$$

$$N = 46$$

The signs of the coefficients are all as expected. The coefficient on the income term is insignificant at the 95% level, although it is significant at the 90% level.

LITTER AND ADMINISTRATIVE COST

Litter and Resource Recovery

The empirical evidence presented above for Grand Rapids provides little or no support for a non-zero price elasticity. An indirect test for such an effect would be to look for an increase in litter related to price increase. No direct measure of litter was available; as a proxy variable we used quantity of waste collected in city parks (see Table 19). A simple test of the litter hypothesis is to see whether this quantity is significantly related to the level of the real price of bags. The following equation was therefore estimated:

$$\ln(L) = b_0 + b_1 \ln(P_{BAG}) + b_2 s \qquad (57)$$

where L is the monthly total of parks refuse, P_{BAG} is real price per bag, and s is a seasonal dummy.

The following results were obtained (standard errors in parentheses) using ordinary least squares:

$$\ln(L) = 14.0 + \underset{(5.5)}{5.4} \ln(P_{BAG}) - \underset{(0.69)}{0.65}WIN + \underset{(0.67)}{0.95}SPR + \underset{(0.65)}{1.65}SUM$$

$$R^2 = .28$$
$$N = 45$$

The signs of coefficients are as expected, but only the dummy coefficient for summer is significant at the 95% level, although the price coefficient is significant at the 83% level. Hence the available data make it impossible to reject the null hypothesis that price changes have no effect on littering. Although the quality of these data is poor, the conclusion is supported by impressions of Refuse Division personnel that price increases have not resulted in noticeable increases in litter.

Although there are several firms in Grand Rapids which deal in scrap metal and recycling of industrial and commercial waste, we discovered only one, Recycle Unlimited, which deals primarily with recycling of household solid waste. This small, non-profit organization maintains thirteen locations in Grand Rapids where residents may deposit papers and glass, plastic, or metal containers for recycling. The Refuse Division cooperates with this organization, but neither the Division nor the Kent County Public Works Department, which operates county landfills, has recycling programs of its own. Two years ago, at the insistence of a group of citizens, a program was started to compost leaves collected by the city, but this was discontinued when no market or other outlet could be found for the composted product.

Administrative Costs

In comparison with other types of user charges, a metered-bag system results in the elimination of administrative costs associated with billing, monitoring service levels, and recording service starts and stops to households. On the other hand, the system incurs costs of order, delivery, and the sale of bags and tags, which are not present in other systems. All user charge systems involve some costs of clerical labor. Direct personnel commitments in Grand Rapids include one-third of a secretary's time and that of a full-time clerk, a total cost of about $15,000 annually. Tags cost the city $3.83 per thousand, or about 3% of their retail price. Bags cost the city $59.75 per thousand. In addition, commercial retailers, who account for about 62% of sales, are given 4% of these revenues.

In 1976 a Columbia University study [11] found that on average 3.1% of total collection costs were due to billing costs in cities with municipal collection and user charges, based on a sample of 39 cities. If we assume that, as with tags, 97% of the price of a bag in Grand Rapids constitutes payment for service plus the value of the bag, then payments in lieu of billing are about 5.5% of the user fee (.03 + .04 x .62). However, there are at least two reasons why the "billing" costs of the metered-bag system may be considered somewhat less. First, the public relations benefits alluded to earlier mitigate some expenses, although these benefits are difficult to quantify. And second, revenues from sales cover only about 45% of total operating costs, so that "billing" costs are only about 2.5% of this total.

This brings us to another interesting aspect of the metered-bag system -- the fact that in general service is non-mandatory, although in Grand Rapids some payment is mandatory for all households. Municipal service is non-mandatory in two senses. First, licensed private haulers are allowed to compete for customers and do so successfully, a particular characteristic of Grand Rapids; and second, households are not required to present any minimum number of bags each week as is the case with other types of user charges, a general characteristic of the bag system. At the same time, most of the costs of municipal service are financed out of general funds, so these costs are borne by all taxpayers as a mandatory fee, albeit one which varies with the taxes paid by each invidual household.

This situation arose historically because the user fee was originally intended to cover only the added costs resulting from the change to combined collection rather than to cover full costs. Initial estimates on this basis were that user fees should cover about 40% of full costs, and this proportion has been roughly maintained as we saw in Table 25. This means, of course, that the user charge system is not self-financing and that apartment dwellers and other households with private collection may subsidize municipal customers. On the other hand, it could be argued that refuse collection is in some ways a public good and that since the municipality must accept all refuse presented in city bags, it acts as a "collector of last resort." The inefficiencies associated with having more than one collector in a geographical area are therefore created by households who demand collection by private haulers, according to this argument.

These arguments were not articulated by the Environmental Protection Department in Grand Rapids, however, and we shall not develop them further because they raise questions concerning the equity of user charges which are beyond the scope of this study. Our purpose in raising the issue is to point out that a user charge system may be combined with tax-based financing, but only at the risk of losing the alleged advantages of a self-supporting operation, and that particular charge structures are often rooted more deeply in historical circumstances than in economic theory.

Cost data available in Grand Rapids after July 1976 were used to estimate cost functions for the period since that date. This in turn made it possible to estimate bag and tag prices which would be required in order to equate marginal revenue to marginal cost. As an example, consider data from the month of September 1977. Using cross-sectional data on eighteen trucks used during that month, the following function was estimated:

$$\ln C_i = \ln a + b \ln TONS_i \tag{58}$$

where C_i is the direct operating cost of truck i and $TONS_i$ is the quantity in tonnes of waste collected by truck i. The results, using ordinary least squares (t-statistics in parentheses), were;

$$\ln C_i = \underset{(9.5)}{3.8} + \underset{(10.0)}{.81} \ln TONS_i$$

$$R^2 = .86$$

This implies an average cost of

$$C/TONS = a\ TONS^{b-1} \tag{59}$$

and a marginal cost of

$$\partial C/\partial TONS = b\ a\ TONS^{b-1} \tag{60}$$

Evaluating average cost directly from total tonnage and direct cost gives an average cost per tonne of $20.69; substituting in equation (60) gives a marginal cost of $16.83 per tonne.

Revenue per bag sold through commercial outlets is $.192 x .96 = $.184. From Table 27, average weight per bag in 1976 was 9.9 kilograms, so one tonne of collected waste went into roughly 100 bags. Marginal cost for collection and disposal of one tonne of waste, therefore, is $5.98 for cost of bags plus $16.83 for collection plus $6.16 for disposal, a total of $28.97. Marginal revenue for collection of one tonne of waste was $18.40. To bring marginal revenue up to marginal cost would require a price increase of about 57% to $.30 per bag or $3.60 per dozen. By a similar argument, marginal revenue from 100 tags was $23.37. To bring marginal revenue up to marginal cost in this case would have required a 95% increase to $2.45 for 10.

The above calculations were carried out for each month for which data were available; the results of this analysis are shown in Table 23. During the time in question, the cost of disposal rose from $6.06 per tonne to $6.16 per tonne in August 1977, and, as shown in Table 26, cost of bags rose from $53.60 per thousand to $59.75 per thousand in March 1977. The price of bags and tags remained the same throughout; no estimate of marginal revenue was made on a monthly basis, however, because of lack of reliable information on number of bags actually collected. Figures for February 1978 are excluded from averages in Table 23 because of the effect of introducing new side-loaders into the collection fleet.

A pooled estimate of the cost function shown in equation (56) was made using data from 15 trucks used throughout the period July 1976 to December 1977. The results (standard errors in parentheses) were:

$$\ln C = \underset{(0.2)}{4.2} + \underset{(0.04)}{0.71} \ln \text{TONS}$$

$$R^2 = .52$$

$$N = 234$$

For these 15 trucks, average direct cost per tonne was $18.25, implying a marginal cost of $13.01 per tonne. Tracing once again the argument above, this indicates that a 37% increase in price of bags to $3.15 per dozen and a 63% increase in price of tags to $1.65 for 10 would have covered marginal direct cost during this period.

Finally, pooled data were used to estimate the following equation:

$$\ln C = a + b_1 \ln(\text{TONS}) + b_2 \ln(T) + b_3 \ln(\text{WAGE}) + b_4 \text{HAUL}$$

where T is a time trend, WAGE is average monthly base wage paid to collection personnel, and HAUL is a dummy variable with the value 1 before July 1977, when waste was hauled to a more distant landfill, and 0 thereafter. The results (standard errors in parentheses) of estimating this equation were:

$$\ln C = -15.1 + \underset{(.04)}{.73} \ln TONS + \underset{(.04)}{.11} \ln T + \underset{(1.54)}{2.03} \ln WAGE + \underset{(.10)}{.02} HAUL$$

$$R^2 = .59$$

$$N = 234$$

The signs of coefficients are as expected, but only those for quantity collected and time are significant at the 95% level.

SECTION 9

TACOMA, WASHINGTON

Tacoma, Washington has some fifty years' experience in financing solid waste collection and disposal through user fees. Over the years the city has considered or experimented with most of the various fee systems in current use around the country. The present fee structure is a combination of a container-based system and a location- or service-based system. Hence it provides an example of the effects of combining several fee structures.

Residential households living in single unit or duplex structures (79 percent of all households) receive mandatory weekly collection at a rate determined by the number of containers presented for collection and the level of carryout service provided. Households presenting refuse within 7.6 meters of a legal collection point (usually curbside, but alleys in some districts) are charged $2.45 per month for the first can and $1.15 per month for each additional can. Those presenting refuse between 7.6 and 22.9 meters from collection points are charged $3.90 for the first can and $2.65 for each subsequent can. Between 22.9 and 61.0 meters, and over 61 meters, the base prices are $5.30 and $6.65 and marginal prices are $4.05 and $5.45, respectively. A charge of $1.60 times the number of cans is levied for each flight of up to six stairs between points of collection and presentation. These are monthly fees paid along with electricity, water, and sewage bills on a monthly or bimonthly basis. In addition, occasional extra bags of refuse left alongside regular cans are collected for a charge of $.75 each. Residents are required to pay for the minimum service of one can at less than 7.6 meters; about 30% of residential customers demand some level of optional service, a proportion that has steadily increased historically. Records from 1954 and 1958 indicate that in those years about 92% of all households received the minimum level of service; in recent years the figure has been about 75%. Households living in structures of three or more units are charged jointly for service at commercial rates. Finally, Tacoma residents may haul extra refuse to the city landfill and dispose of it at no charge; about 40% of all household refuse by weight is disposed in this way.

Income elasticities consistent with previous findings were found in Tacoma, although they were not significant at the 95% level. Tacoma was the only city among those studied where significant price elasticities were found; this finding is complicated by the fact that there are two price elasticities of interest -- one for incremental containers and one for location. The finding of a positive price elasticity for container price suggests that some type of specification error may be the cause.

This section contains a description of Tacoma's solid waste system, some of the data on the system which we collected, a theoretical model of the user fee structure found in Tacoma, and our conclusions about the fee system.

THE TACOMA SOLID WASTE SYSTEM

Tacoma's solid waste system is constituted as a classified utility under the Department of Public Works. This is an intermediate form between a department of local government and an independent public utility. Like most public utilities, the solid waste system must finance its operations (including capital expenditures, debt service, and taxes) out of revenue it collects rather than from general funds, and its staff, equipment, and land are autonomous from local government. But unlike many utilities, its governing board is the city council rather than a separate utilities commission. Following the taxonomy developed by Savas [12], this is very close to a franchise system whereby the municipality is the service arranger and a "private" firm is the mandatory service provider and fee collector, except that the franchise must always go to a single firm "owned" by the municipality.

Collection of Residential Waste in Tacoma

Tacoma operates a fleet of 33 collection trucks, 22 of which serve residential routes. Refuse is collected once a week from each residential customer, and crews work a five-day week. Trucks are operated by two-man crews sharing driver and collector responsibilities. The driver carries a route book listing name, address, and current service level of each customer, and in which a record of extra bags collected and changes in service are kept. Three route supervisors handle most customer requests such as requests for extra collections or service changes, and reports of unsanitary conditions. The route supervisor posts were created between 1973 and 1975 at the same time as collection crew size was reduced from three to two. The change in staff structure is felt to have resulted in reductions in paperwork, more efficient routing, and improvements in safety, equipment operation, and customer relations and service. Employees of the Refuse Utility have been organized in the Teamsters Union since the 1940's; labor relations have been good in recent years.

The last major restructuring of refuse collection took place in 1929 when the Refuse Utility was inaugurated. Refuse had previously been collected by private haulers on a purely voluntary basis. Of some 24,000 households living in Tacoma at the time, only 6,000 subscribed to collection services, and while most of the rest disposed of their own refuse in a satisfactory manner, enough did not as to create a serious health hazard from garbage left in streets, on vacant lots, and along roads on the edge of the city. One of the first actions of the new utility was a massive clean-up campaign. A dump site was created in the swamp on the eastern edge of the city which was used for over thirty years, creating land for industrial development over former tidal flats.

While the absence of legal constraints on household behavior gave rise to social problems and consequent reorganization of solid waste collection fifty years ago, an increase in legal constraints, among other factors, has stimulated discussion of changes more recently. Laws prohibiting the burning of household refuse came into effect in 1968 which resulted in an increased quantity of refuse presented for collection. Total quantity of refuse disposed increased by about 70% from 1968 to 1969; quantity of household refuse collected by the city and self-hauled by residents grew at the same rate. In July 1968 consideration was given to switching to a flat-fee structure on a trial basis. This plan was rejected because it was felt it would be difficult to revert to a variable fee after the trial period and because it was felt that a flat-fee would bring about an even greater increase in the quantity presented for collection. The experience of Seattle seems to have influenced Tacoma's decision: in 1964 Seattle had gone to a flat fee, and the number of containers presented went from about 1.75 cans per household to between two and three cans. The number of cans presented in Tacoma seems to have remained fairly constant at about 1.25 since 1969.

From an historical perspective, user fees in Tacoma have gradually shifted from being primarily location-based to being increasingly quantity-based. The original fee structure introduced in 1929 varied only according to pickup location; this was at a time when almost all households probably demanded one can per week or less. Since the introduction of a variable fee for quantity collected in 1938, the marginal rate for added quantity has steadily decreased as a proportion of the basic rate for minimum service, while the marginal rate for added location-based service has increased relative to the basic rate.

Further evidence of increased orientation toward quantity-based fee variations can be seen in the consideration between 1974 and 1976 given to several versions of the "bag" system, whereby residents would be required to place rubbish in bags whose price includes the cost of collection and disposal. It was estimated in 1974 that $50,000 to $100,000 in revenue were lost annually by not charging for bags left for collection by households who had extra refuse occasionally, but not often enough to warrant purchasing an additional can of weekly service. In April 1974 the Utilities Service Director put forward a plan to sell plastic bags through the city's fire stations for 50 cents each to be used for these "occasional extras." Consideration was also given to making a complete changeover to the bag system for all household refuse collection. This latter plan was rejected for several reasons: it would require changing the city's ordinances regarding the storage of refuse in rodent-proof containers; it was felt that plastic bags were too expensive (13 to 14 cents each); and paper bags would deteriorate in the damp climate. Because of problems with arranging for distribution of bags, the more limited bag system for extras only was rejected also -- shops and supermarkets were generally unenthusiastic about serving as retail outlets, and fire stations were not always sufficiently staffed.

An alternative to the bag system was finally adopted in May 1976. Collection crews are given cards on which to note the address and number of bags for any extra pickups; a clerk records this information along with the account number of the address where the extras were left, and the customer is billed at the end of the month. The price of this service is set at a level that makes it cheaper for households to use an extra can all the time if they have an extra bag of refuse at least twice a month on average. During the first year this system was estimated to have cost about $17,000 while developing added revenues of about $69,000.

Disposal of Waste in Tacoma

Tacoma is fortunate in having a landfill inside its city limits, less than thirteen kilometers from any point in the city (see Figure 20). Hauling costs for both the city and private residents taking refuse to the landfill are considerably less than they might be if the landfill were outside the city, so a great deal of effort has been devoted to prolonging use of the present site. The original landfill in former swampland on the eastern edge of the city reached capacity in 1960, when the present landfill, a ravine southwest of the city center, was acquired. The 81 hectare site of the ravine was originally expected to serve Tacoma's disposal requirements for ten years, but cost estimates in the mid-sixties indicated that to prolong the life of the landfill would result in considerable savings since no more suitable sites were available in or near the city. Consequently, several projects have been undertaken with the aim of resource recovery and reduction of the volume of waste disposed.

In 1972 the city acquired a Williams model 680 shredder under an Environmental Protection Agency grant to evaluate the effect of volume reduction of solid waste. During the first year of operation the shredder produced about $4,000 in revenue from the sale of scrap. By 1976 the shredder was processing ten thousand tonnes of refuse (out of 135 thousand tonnes received annually at the landfill) at a cost of about $200,000, and yielding some $7,000 in revenue from sale of scrap. About half the materials processed were demolition material; the remainder consisted of household appliances, scrap metal, wood products, and automobile tires.

Operation of the shredder has been limited by lack of transport facilities for removal of the shredded product, a situation expected to be remedied when a more extensive resource recovery system goes into operation this year. The Refuse Utility has recently acquired a $2.4 million resource plant which separates the shredded waste into light and heavy fractions (in proportions which can be varied) by means of a blower and airstream baffles, separates ferrous metals magnetically, and deposits separated materials into trucks via conveyor belts. It is estimated that this sytem, which became operational in May, will produce about $400,000 annually in revenue from sale of paper, scrap metal, and hogged wood fuel, as well as extending the life of the present landfill by thirty to forty years -- well into the next century. Out of 400 tonnes of refuse received daily, it is expected that 320 tonnes of wood and paper, and 33 tonnes of ferrous metals will be recovered for recycling.

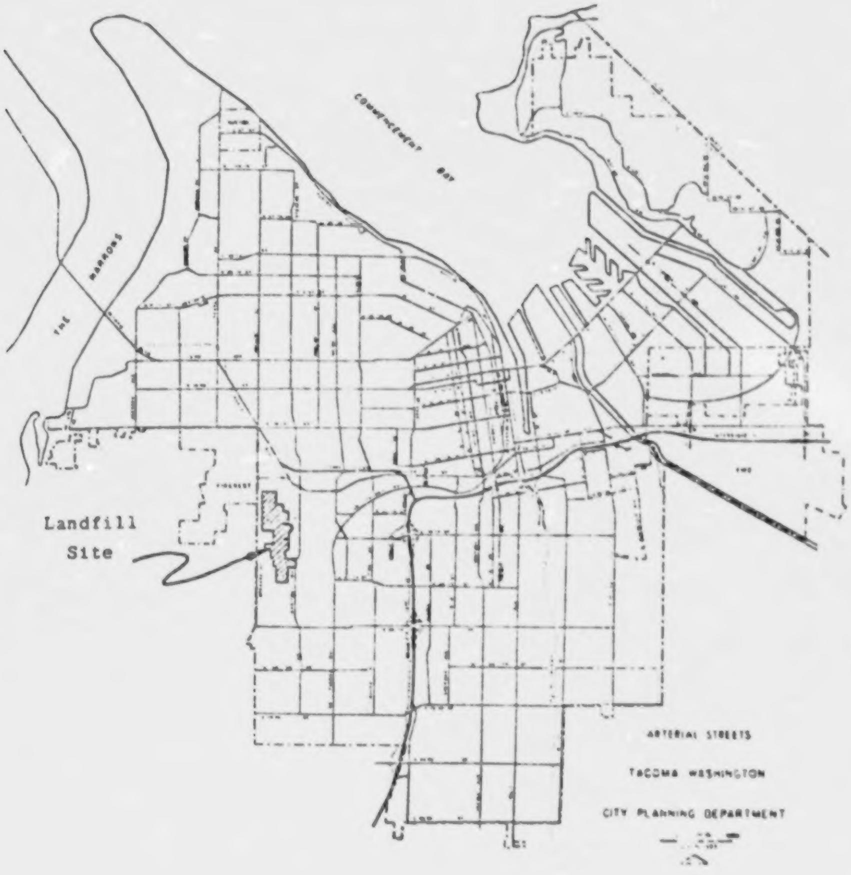

THE NARROWS
COMMENCEMENT BAY
Landfill Site
ARTERIAL STREETS
TACOMA WASHINGTON
CITY PLANNING DEPARTMENT

Figure 20. Map of Tacoma, showing landfill location.

Tacoma's solid waste disposal system serves a total population of about 177,000 -- 157,000 city residents and 20,000 outside the city who either haul their own refuse to the landfill or receive collection service from haulers who utilize the Tacoma landfill. About 3.5% of refuse processed at the city landfill originates outside Tacoma; figures are unavailable on how much waste originating in Tacoma is disposed outside the city, but the amount is probably negligible. The city collects 56% of Tacoma's total (residential and other) solid waste, and another 15% is hauled by residents to the landfill. Since 40% of the city's collection is from residential sources, household solid waste accounts for 37% of the total generated in the city (15% + 40% x 56%), or about 1.2 tonnes/household annually. The user fee charged to Tacoma residents for household collection includes a charge for disposal of $6.17 per tonne. Commercial haulers are charged $6.17 per tonne for refuse originating in Tacoma, with a $3.00 minimum charge and a $1.25/hour dumping fee for each hour per load over 1 hour. Commercial haulers are charged $9.92 per tonne for refuse originating outside Tacoma, with a $5.00 minimum, and private residents from outside Tacoma are charged $3.15 for refuse brought to the landfill in cars and $5.00 for refuse brought in pickups. Tacoma residents are allowed to bring household refuse to the landfill in cars or pickups free of charge.

Administration of the System

Tacoma's experience in finding a way to collect user fees for extra bags of refuse illustrates some of the advantages and disadvantages of a combination fee structure. Because the fee structure has several parts (varying according to number of containers, distance from collection point, etc.) it has been possible to adjust the relative prices of these items as costs have changed. In turn, this has meant that economic constraints have been available in place of legal constraints such as limits on quantities or pickup location. One of the alleged benefits of the bag system is the elimination of administrative costs associated with recording service levels and billing each household separately. But in order to realize this benefit Tacoma would have to eliminate location-based variables from its fee structure, since these require separate records and billing in any case. For Tacoma, the card system involved few additional administrative costs while still yielding most of the benefits of the bag system. In general, once a particular fee structure is adopted it may be costly to modify service or price. A combination fee structure is flexible in allowing piecemeal changes in one of several areas independently, but inflexible because changes must be compatible with all parts of the current system.

Judging from press reports, records of council debate, and numbers of complaints, the Tacoma Refuse Utility has caused little public dissatisfaction or political controversy in recent years. The price of collection and disposal in Tacoma has been consistently less than in Seattle and elsewhere in the region. There have been press reports of sharp debate over municipal vs. private collection and of allegations of inefficient service in some communities in the region, but none in Tacoma.

Since 1970 the Refuse Utility has recommended two fee increases and one fee modification (the addition of the charge for extra bags). On each of these occasions the council was satisfied that the fee increases were justified. Each time, the council considered one proposal to abolish the Refuse Utility in favor of private collection on a contract basis and another proposal to apply reduced rates for carryout service to elderly and disabled residents; both proposals were rejected each time by votes of 8 to 1. No conclusions can be drawn from such fragmentary observations except to say the the Refuse Utility is at worst not sufficiently inadequate for another system to be seriously considered and at best superior to any available alternative.

DATA COLLECTED

Data on Quantities Disposed

Records are kept on a monthly basis of quantities disposed at the Tacoma landfill. Tonnage of waste self-hauled by city residents and tonnage collected by city packer trucks is shown in Table 28 for the years 1974 through 1977. During these years packer collection accounted for 40% to 50% of total city collection, the remainder coming from commercial sources. Packer routes covered all households with individual accounts (those paying user fees), multi-family residential dwellings with caster-box service, and a small amount of waste from commercial sources. These figures therefore over-state the quantity of waste generated by households paying user fees, and to a lesser extent they over-state the quantity of collected residential waste. However, it was impossible to estimate precisely the extent of this inflation from data available. When annual totals were compared with estimated quantities listed in annual reports of the Refuse Utility (see Table 32 below), it appeared that between 6% and 15% of refuse hauled by packers came from commercial sources and that between 62% and 92% came from households paying user fees.

Figures 21 and 22 illustrate the information from Table 28 on quantities of household waste collected and self-hauled. Quantity of waste collected appears to be rising very slightly over time, although most of this increase is due to population growth, so that waste collected per household is rising less sharply (cf. Table 32). Quantity of waste collected also shows very little seasonal variation. Most of the annual drop in February stems from its having fewer days. Quantity self-hauled clearly exhibits seasonality, rising from a minimum in January to a maximum in June. Quantity self-hauled also appears to be increasing over time, at a rate larger than the increase in quantity collected. Figure 22 combines the two lines in Figure 21 to show the relative proportions of household waste collected (reading from the lower edge) and self-hauled (reading from the upper edge). Seasonality due to variation in quantity self-hauled is apparent.

Because disposal of self-hauled waste is free of charge to city residents, the only costs to households for this option are transportation

TABLE 28. QUANTITY[1] OF WASTE DISPOSED, TACOMA

Date	Residential[2] waste collected	Self-hauled by city residents	Other waste collected from non-commercial sources [3]
Jan. 74	3,879	555	126
Feb. 74	3,408	759	54
Mar. 74	3,772	1,263	77
Apr. 74	4,499	1,972	71
May 74	4,243	2,166	83
Jun. 74	3,734	2,381	50
Jul. 74	4,068	2,008	83
Aug. 74	3,820	1,945	86
Sep. 74	3,767	1,686	119
Oct. 74	3,786	1,428	230
Nov. 74	3,752	1,005	33
Dec. 74	3,882	757	83
Jan. 75	4,098	1,046	252
Feb. 75	3,395	1,007	98
Mar. 75	3,550	1,545	151
Apr. 75	3,777	2,334	96
May 75	3,890	2,510	99
Jun. 75	3,639	2,448	90
Jul. 75	4,042	2,052	75
Aug. 75	3,704	2,153	94
Sep. 75	3,984	1,863	258
Oct. 75	4,167	1,313	72
Nov. 75	3,604	1,132	65
Dec. 75	4,072	776	90

(continued)

TABLE 28 (continued)

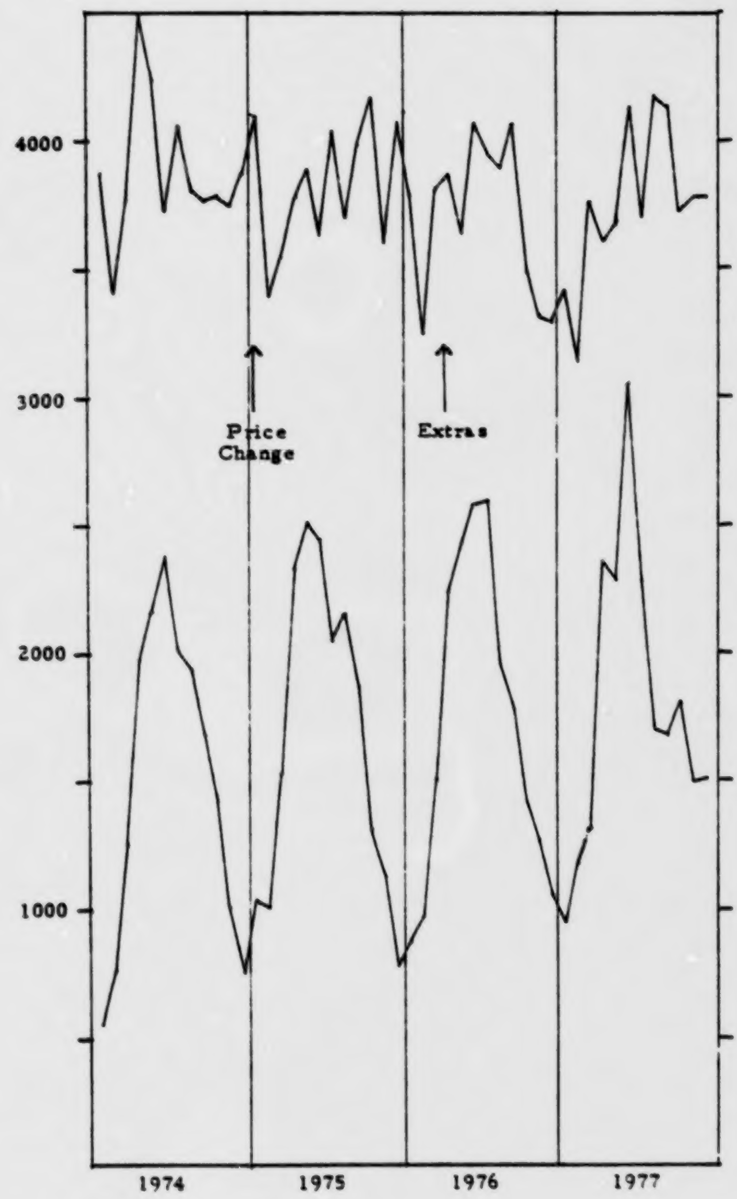
Date	Residential waste collected	Self-hauled by city residents	Other waste collected from non-commercial sources
Jan. 76	3,786	877	40
Feb. 76	3,253	971	37
Mar. 76	3,810	1,505	46
Apr. 76	3,871	2,243	19
May 76	3,646	2,432	20
Jun. 76	4,071	2,580	16
Jul. 76	3,948	2,594	16
Aug. 76	3,895	1,955	22
Sep. 76	4,069	1,779	39
Oct. 76	3,488	1,423	2
Nov. 76	3,819	1,267	18
Dec. 76	3,797	1,055	27
Jan. 77	3,413	953	20
Feb. 77	3,142	1,171	52
Mar. 77	3,755	1,313	16
Apr. 77	3,604	2,356	13
May 77	3,687	2,280	22
Jun. 77	4,131	3,050	41
Jul. 77	3,700	2,278	23
Aug. 77	4,167	1,701	30
Sep. 77	4,133	1,680	33
Oct. 77	3,727	1,805	14
Nov. 77	3,771	997	11
Dec. 77	3,770	1,004	16

1/ All quantities in tonnes.

2/ Total collected by all packer trucks.

3/ Used as proxy for litter.

Source: Tacoma Refuse Utility.



Top line - quantity collected.
Bottom line - quantity self-hauled.

Figure 21. Tonnes of household solid waste, Tacoma.

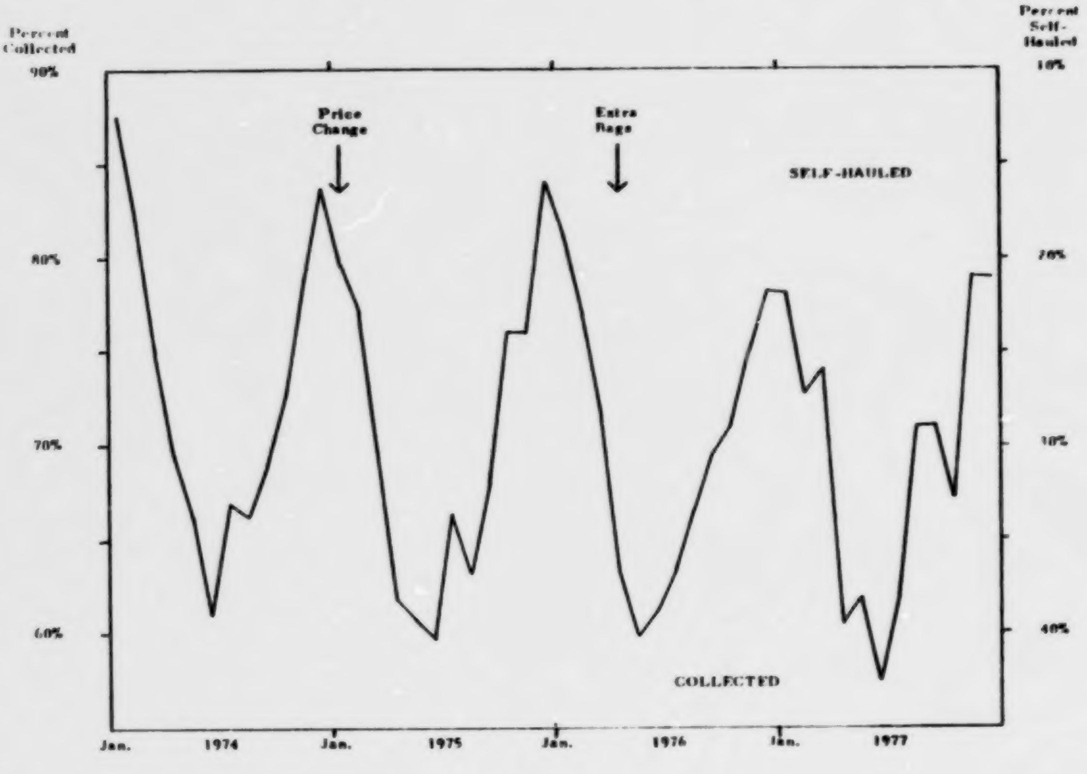


Figure 22. Percent of household waste collected and self-hauled.

costs and opportunity costs of alternative activities. Assuming these remain fairly constant, we would expect one effect of a price increase for marginal cans to be an increase in self-hauling. In rough terms this appears to be the case. In 1974, 73.2% of household waste was collected rather than self-hauled. After a price increase in January 1975 the figure fell to 70.2% for that year. The only other price change was a charge of $.75 for extra bags introduced in April 1976, just before the summer months when self-hauling peaks. Further substitution of self-hauling for collection seems to have ensued -- percentage of total waste collected dropped again to 69.6% for 1976 and remained at that level for 1977.

Further effects on household behavior can be seen in Figures 23 and 24, which illustrate, respectively, the number of extra bags collected each month and kilograms of waste per container (can or bag) each month. Two trends are apparent in the first 19 months of operation of the extra bag charge system -- a seasonal variation similar to the one observed for self-hauled quantities, combined with an exponential decline in the number of extra bags presented. The exponential decline suggests the presence of a "learning curve" in response to this particular fee modification. Perhaps in the early months of the extra charge households continued to leave the same number of extras, and only after they were billed did some begin to substitute self-hauling or to order an extra can on a permanent basis. Response time is longer than one or two months because fewer than 25% of households incur the charge in any given month.

Figure 24 illustrates the effect of the extra bag charge system on stuffing behavior. In each of the two 12-month periods prior to introduction of the system, 16.3 kg. per container were left for collection. During the first twelve months of the extra bag charge system, 16.0 kg. per container were left for collection if extras are not counted, and 14.3 kg. per container if extras are counted. In the seven subsequent months the figures are 16.9 kg. and 15.3 kg., respectively. These differences are significant at the 90% confidence level. It would seem that before the extra bag charge system was instituted households left extra bags rather than ordering extra cans, so that the recorded quantity per container ordered includes quantities effectively "stuffed" into containers. The extra bag charge system stopped this practice. The meaning of the subsequent increase in waste per container is unclear, partly because the increase is not statistically significant, and partly because such an increase could be due either to households literally stuffing containers more full or to households using containers more efficiently by storing extra waste on their premises.

Finally, the quantity of waste collected from other non-commercial sources was found to bear no significant relationship to quantities of residential waste self-hauled or collected, or to price changes. To the extent that this is a suitable proxy for litter and other forms of illicit or socially costly disposal, we may infer that Tacoma's user charge system has no significant effect on littering behavior.

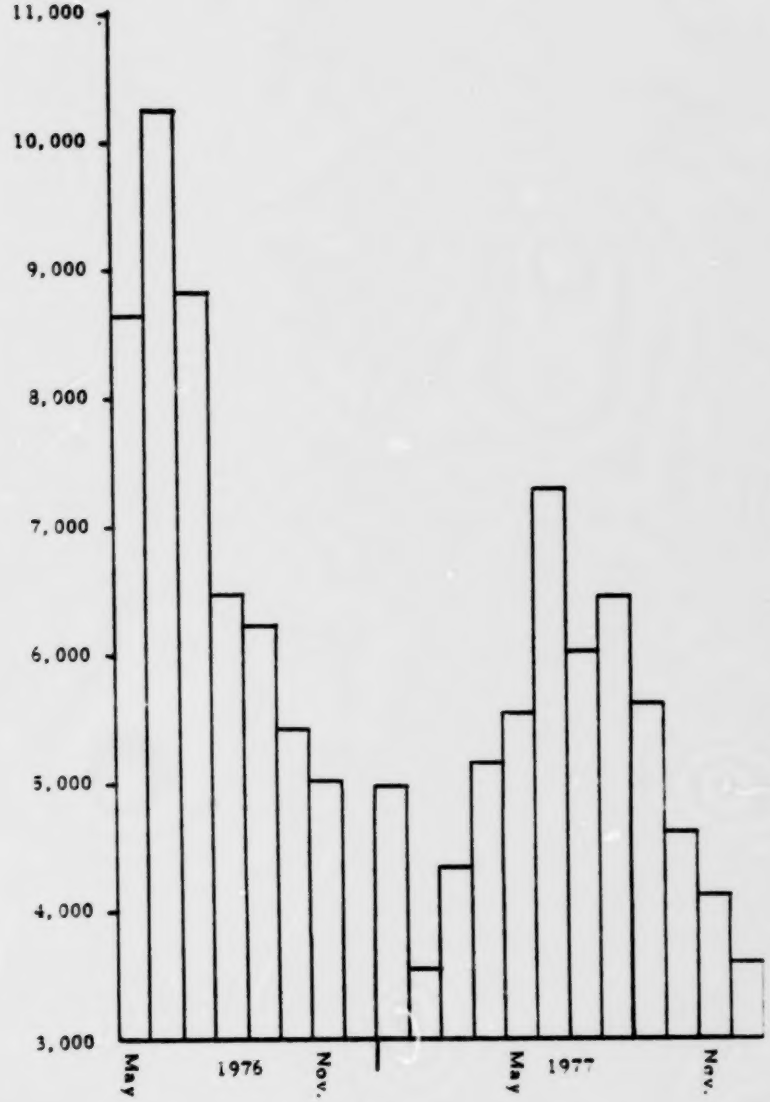
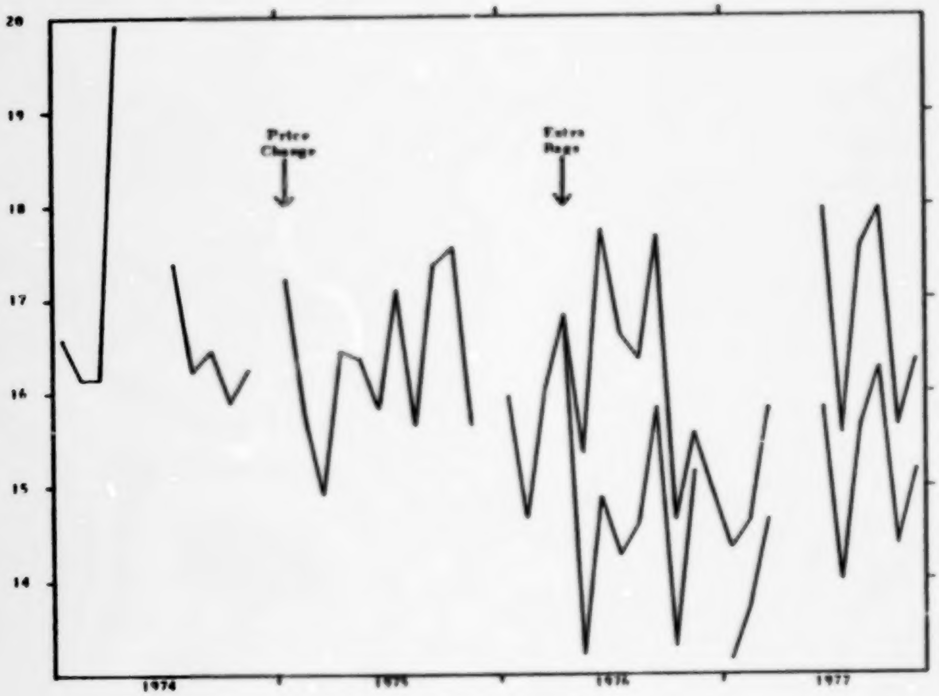


Figure 23. Number of extra bags collected, Tacoma.



N.B.: Upper line excludes extras; lower line includes extras.

Figure 24. Kilograms per container collected.

Data on Collection

Data on collection are from two sources: historical records of the Refuse Utility, which contain price schedules and fragmentary information about the history of the Utility dating back to 1929, and billing records, available back to January 1973, which show the number of households billed at each separate level of service (by number of cans, number of stair flights, and increment of carryout service), and total number of extra bags billed. Price schedules for residential collection effective January 1973 and January 1975 are given in Table 29. Data on numbers of households at various service levels are summarized in Table 30 and illustrated in Figures 25, 26, and 27.

TABLE 29. PRICES FOR RESIDENTIAL COLLECTION

Price schedule effective January 1973:

	Distance from collection point*			
No. of cans	0-25 ft.	25-75 ft.	75-200 ft.	Over 200 ft.
1	$1.75	$2.65	$3.55	$ 4.50
2	2.60	4.45	6.25	8.15
3	3.45	6.25	8.95	11.80
4	4.30	8.05		
5	5.15	9.85		
6	6.00			

* Add $1.00 per can for each flight of stairs carried.

Price schedule effective January 1975:**

	Distance from collection point*			
No. of cans	0-25 ft.	25-75 ft.	75-200 ft.	Over 200 ft.
1	$2.45	$ 3.90	$ 5.30	$ 6.65
2	3.60	6.55	9.35	12.10
3	4.85	9.20	13.40	17.55
4	6.00	11.85		
5	7.15			
6	8.30			
7	9.45			

* Add $1.60 per can for each flight of stairs carried.

** Effective April 1976, add $0.75 for each extra bag left for collection.

Source: Tacoma Refuse Utility.

TABLE 30. NUMBER OF HOUSEHOLDS SELECTING VARIOUS SERVICE LEVELS

Month	No. of households	Households with min. service	Households with more than one can	Households with carryout service	Extra bags
Jan. 73	39,531	29,178	9,943	558	0
Feb. 73	40,347	29,598	10,336	557	0
Mar. 73	40,497	29,925	10,180	537	0
Apr. 73	39,680	29,439	9,858	527	0
May 73	40,043	29,389	10,267	531	0
Jun. 73	39,988	29,197	10,405	525	0
Jul. 73	39,973	29,060	9,943	514	0
Aug. 73	40,036	29,034	10,336	513	0
Sept. 73	40,193	20,085	10,180	515	0
Oct. 73	40,334	29,162	9,858	514	0
Nov. 73	40,440	29,217	10,267	513	0
Dec. 73	40,528	29,351	10,405	513	0
Jan. 74	40,566	29,387	10,799	511	0
Feb. 74	40,513	29,381	10,750	511	0
Mar. 74	40,504	29,398	10,723	508	0
Apr. 74	40,506	29,366	10,761	505	0
May 74	NA	NA	NA	NA	0
Jun. 74	NA	NA	NA	NA	0
Jul. 74	40,326	28,968	10,985	496	0
Aug. 74	40,507	29,020	11,116	497	0
Sept. 74	40,654	29,050	11,235	493	0
Oct. 74	40,939	29,308	11,261	493	0
Nov. 74	41,114	29,579	11,155	505	0
Dec. 74	NA	NA	NA	NA	0
Jan. 75	41,716	30,751	10,386	466	0
Feb. 75	41,735	30,639	10,393	462	0
Mar. 75	41,766	30,846	10,372	456	0
Apr. 75	41,786	30,928	10,338	458	0
May 75	41,814	31,013	10,311	453	0
Jun. 75	41,823	31,048	NA	NA	0

(continued)

TABLE 30 (continued)

Month	No. of households	Households with min. service	Households with more than one can	Households with carryout service	Extra bags
Jul. 75	41,652	30,912	10,386	466	0
Aug. 75	41,666	30,924	10,393	462	0
Sept. 75	41,801	31,082	10,372	456	0
Oct. 75	41,951	31,264	10,338	458	0
Nov. 75	42,083	31,427	10,311	453	0
Dec. 75	NA	31,524	NA	NA	0
Jan. 76	42,093	31,596	10,156	444	0
Feb. 76	42,102	31,654	10,106	447	0
Mar. 76	42,157	31,760	10,055	446	0
Apr. 76	42,355	31,947	10,067	445	0
May 76	42,201	31,735	10,123	445	8,659
Jun. 76	42,151	31,668	10,144	439	10,250
Jul. 76	42,140	31,601	10,203	436	8,828
Aug. 76	42,199	31,596	10,272	435	6,448
Sept. 76	42,233	31,648	10,258	430	6,240
Oct. 76	42,319	31,764	10,231	427	5,424
Nov. 76	42,381	31,895	10,163	426	5,058
Dec. 76	42,452	32,019	10,108	426	NA
Jan. 77	42,467	32,119	10,023	427	4,922
Feb. 77	42,468	32,169	9,975	426	3,543
Mar. 77	42,498	32,246	9,931	422	4,347
Apr. 77	NA	NA	NA	NA	5,167
May 77	NA	NA	NA	NA	5,572
Jun. 77	42,707	32,553	9,831	421	7,277
Jul. 77	42,760	32,661	9,776	418	6,021
Aug. 77	42,737	32,639	9,776	417	6,455
Sept. 77	42,800	32,713	9,768	414	5,647
Oct. 77	42,974	32,913	9,744	412	4,685
Nov. 77	43,060	33,044	9,702	407	4,173

Source: Tacoma Refuse Utility.

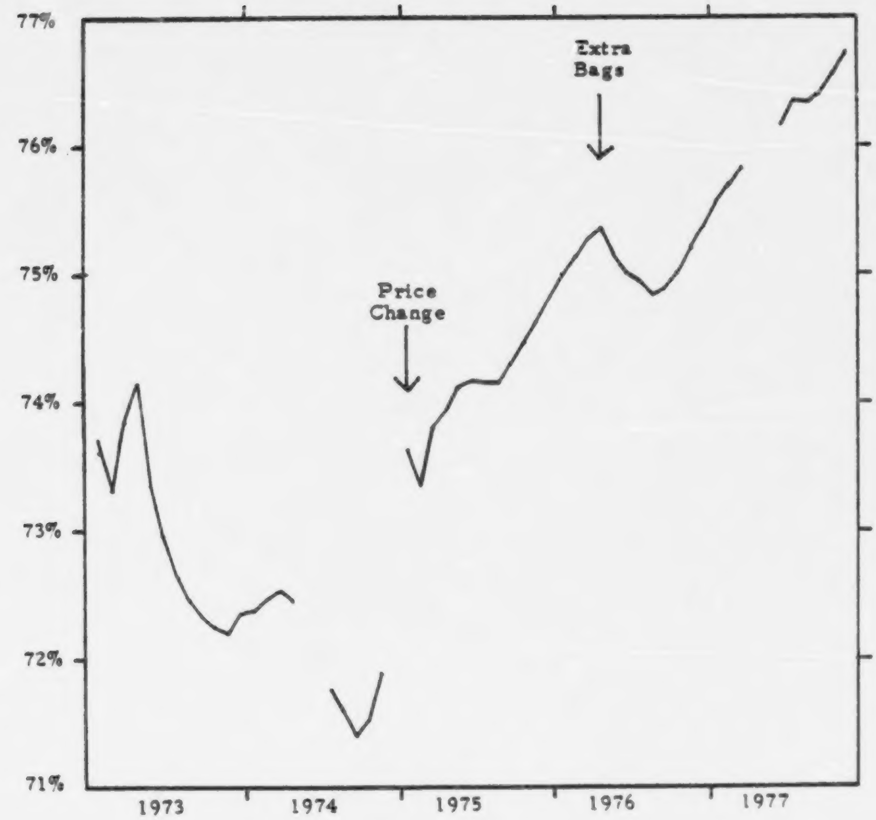
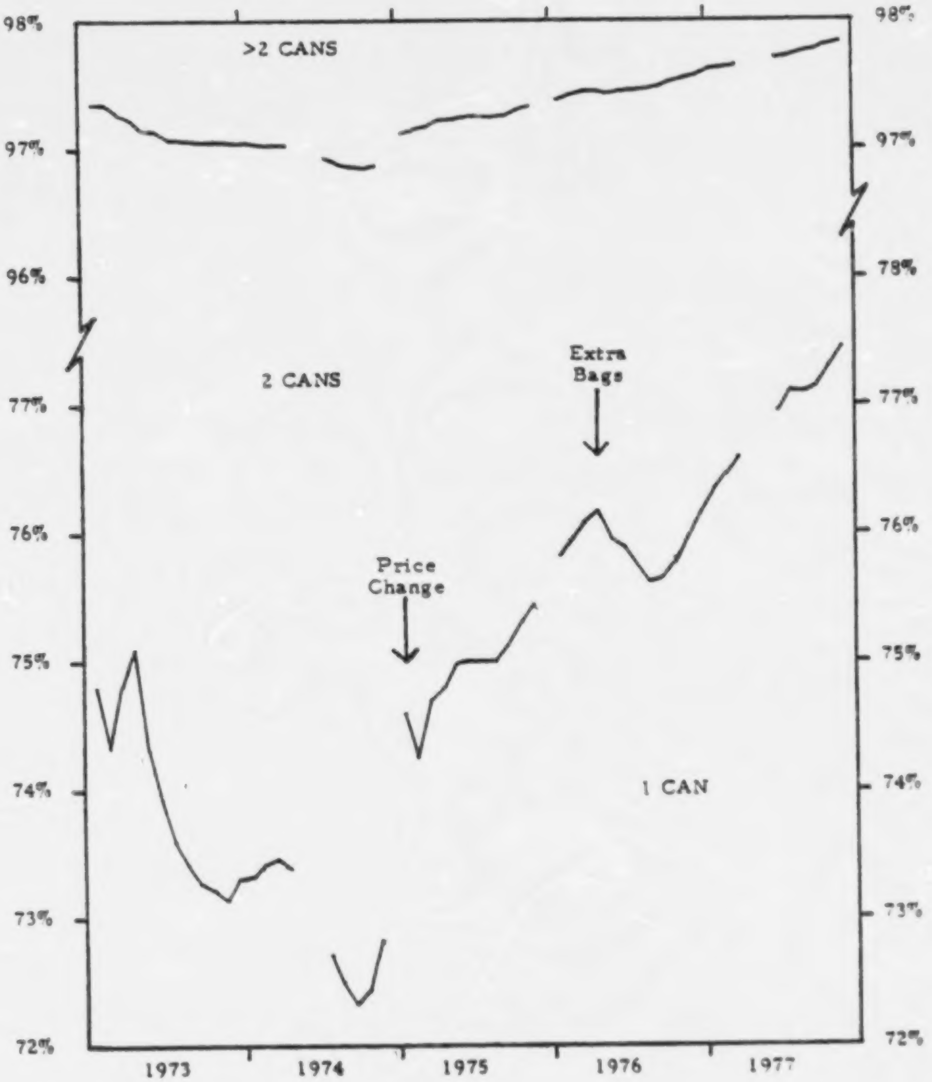


Figure 25. Percent of households at minimum service level.



N.B.: Top Line - Households with 1 or 2 cans.
Bottom Line - Households with 1 can.

Figure 26. Percent of households at various quantity levels.

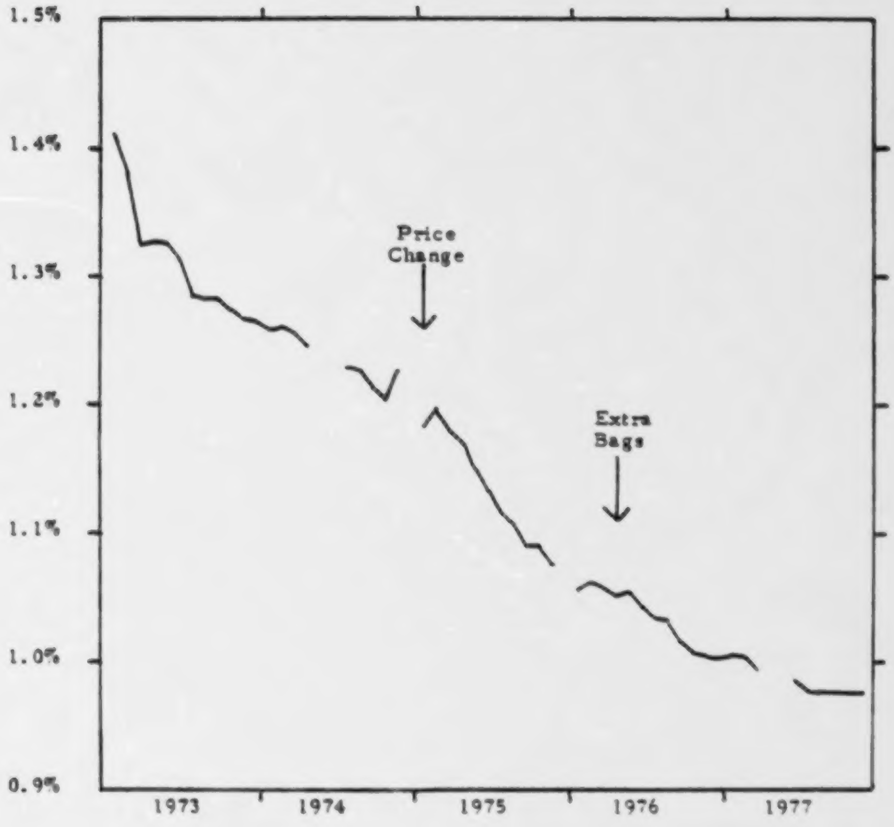


Figure 27. Percent of households with carryout service.

We noted earlier that only households in single-unit or duplex structures are separately billed for solid waste collection. Figure 25 illustrates the percentage of such households demanding the minimum required service -- one can at curbside (or alleyway) location. The short-run effect of price changes is as expected from initial inspection of Figure 25. The price increase in January 1975 leads to an increase in the percentage of households demanding minimum service, as the marginal price of additional service becomes greater than willingness-to-pay for some households. The introduction of extra bag charges leads to a decrease in percentage demanding minimum service, as some households order extra cans rather than incur charges for extras. The longer-run effects are more puzzling, however. During periods between price changes, the overall increase in personal income (using retail sales tax receipts, Table 31, as a proxy for this variable) results in a gradual decline in real price. We expect this to lead to a corresponding decrease in percentage of households demanding minimum service. Furthermore, historical records show that in 1954 and 1958 about 8% of households demanded additional service, indicating a long-term increase in demand for additional service. In 1973 and 1974 the percentage demanding additional service increased as expected, but during the years 1975-1977 the percentage declined steadily. It is unclear whether this represents a departure from a long-term trend or the result of a fall in real income.

TABLE 31. TAXABLE RETAIL SALES*
CITY OF TACOMA, 1973-1977

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1973	$152,225,411	$155,985,836	$187,040,079	$188,569,348
1974	179,621,223	181,695,964	190,579,107	214,595,922
1975	186,438,554	208,241,640	214,056,812	224,907,778
1976	197,460,809	221,902,620	228,375,907	250,482,648
1977	219,721,862	245,283,365	246,901,539	296,771,887

* Based upon local 0.5% county/city sales tax collections.

Source: Washington Department of Revenue.

Similar considerations apply when demand for service above the minimum level is broken down into component factors of extra cans and carryout service. Between November 1974 and January 1975, when the price increase took place, 7.4% of the 2-can households switched to 1 can, 7.6% of those at more than 2 cans switched to 2 cans, and 3.8% of the carryout households switched to curbside service. The extra bag charge seems to have led to some 2-can households switching to 1 can and to have had the negligible effect on households at more than 2 cans or on carryout customers. Over the five years for which data are available, demand for extra cans follows the same pattern observed for non-minimum service, while the percentage of households with carryout service declines steadily. Again, the long-term trend is unclear. The 1958 document referred to above showed that 94.2% of all households had only one can in that year, and 2.1% had carryout service.

Data on Administration

The Refuse Utility publishes an annual statistical and cost report which contains extensive information on all aspects of the solid waste system, broken down by type of service (including residential) and between collection and disposal. Information from these reports for the years 1972-1977 related to collection and disposal of residential waste is summarized in Table 32. Becuse these data are only available annually, they were not used for calculations on quantity collected/disposed or level of service demanded in modelling the solid waste system. Some discrepancies between these data and those in other tables may therefore appear. For example, the annual report takes the total number of separate current accounts during the year for number of customers, which neglects turnover of accounts and households billed in any given month. Also, accounting procedures change from time to time, so that figures may not always be strictly comparable from year to year. In the 1977 annual report, the figure reported for total tons of residential waste collected includes an estimate of waste collected from caster boxes at multi-family dwellings. The figure appearing in Table 32 for this item has been adjusted to make it comparable with figures for earlier years. Finally, the figures in annual reports for quantity of waste collected are estimates which take into account the fact that some refuse from packer trucks comes from commercial customers. In Table 32 these appear as in the annual report, which is why they are somewhat less than annual totals from Table 28.

EMPIRICAL RESULTS

The Tacoma case study is useful because it provides an opportunity to evaluate the effects of both container-based and service-based fee structures simultaneously. In addition, the data available in Tacoma was, in general, more complete for econometric purposes than for the other case study cities.

The Model

As discussed above in Section 4, the demand model for a city with a combination fee structure (where the combination of choices is on containers and service) can be expressed as:

$$q = f(C, S, z, y) \tag{61}$$

$$C = g(p_c, S, y) \tag{62}$$

TABLE 32. ANNUAL FIGURES RELATED TO QUANTITY OF HOUSEHOLD SOLID WASTE AND COST OF PROCESSING HOUSEHOLD SOLID WASTE IN TACOMA

	1977	1976	1975	1974	1973	1972
Number of customers (households)	43,484	43,324	43,033	42,975	42,050	41,867
Tonnes collected	32,379	31,051	30,042	29,484	30,427	30,495
Tonnes self-hauled	20,587	20,682	20,178	17,927	16,761	19,866
Total residential waste	52,966	51,733	50,220	47,411	47,188	50,361
Kg collected/wk/household	14.3	13.8	13.4	13.2	13.9	14.0
Kg total annual waste/household	1218.1	1194.1	1167.0	1103.2	1122.2	1202.9
Revenue billed to households[1/]	$ 1,503	$ 1,491	$ 1,421	$ 1,018	$ 1,003	$ 984
Revenue/tonne collected	46.42	48.03	47.29	34.54	32.95	32.28
Revenue/tonne total	28.38	28.83	28.29	21.48	21.25	19.54
Monthly revenue/household	2.88	2.87	2.75	1.97	1.99	1.96
System expenditures, thousands of dollars:						
Direct operating costs	$ 1,148	$ 1,023	$ 945	$ 888	$ 711	$ 740
Total collection costs	1,587	1,282	1,097	1,078	901	906
Disposal costs	268	192	184	142	124	91
Total cost of service	$ 1,855	$ 1,474	$ 1,281	$ 1,220	$ 1,025	$ 997
Disposal cost of self-hauled material	$ 127	$ 128	$ 124	$ 86	$ 69	$ 59
Total	$ 1,982	$ 1,602	$ 1,405	$ 1,306	$ 1,094	$ 1,056
Expenditures per tonne of household solid waste:						
Direct operating costs	$ 35.46	$ 32.86	$ 31.46	$ 30.10	$ 23.37	$ 24.26
Total collection costs	49.01	41.17	36.50	36.56	29.62	29.72
Disposal costs	6.17	6.17	6.13	4.82	4.09	2.99
Total cost, collected waste	55.18	47.34	42.63	41.38	33.71	32.71
Total cost, all residential waste	30.97	30.95	27.97	27.56	23.19	20.99

1/ In thousands of dollars.

Source: Tacoma Refuse Utility.

$$S = h(p_s, C, y) \tag{63}$$

Note that seasonal effects (z) are included for the waste generation function but not for the choice of capacity or service. The reason is that while waste generation may be expected to have seasonal components (as we have seen in the other case studies), the transactions costs associated with regular changing of either number of containers or service levels discourage frequent changes resulting from seasonal effects per se.

If a double log specification is assumed for each of the equations in (61) - (63) above, then the model would appear as:

$$q = a_0 C^{a_1} S^{a_2} y^{a_3} z^{a_4} \tag{64}$$

$$C = b_0 p_c^{b_1} S^{b_2} y^{b_3} \tag{65}$$

$$S = d_0 p_s^{d_1} C^{d_2} y^{d_3} \tag{66}$$

The reader will note that the number of extra bags presented for collection is not included in any of the individual equations of the model. This is because the program did not begin until April 1976 after the last fee increase. Therefore, the only variation in price would be caused by inflation reducing the real price. This, coupled with the fact that one would expect a new program to expand over at least an initial period of time would mean that any correlation between the two series may be spurious.

Estimation

The first step in estimating the model (64) - (66) is to express each of the equations in a linear form. This result is:

$$\ln(q) = \ln a_0 + a_1 \ln C + a_2 \ln S + a_3 \ln y + a_4 \ln z$$

$$\ln(C) = \ln b_0 + b_1 \ln p_c + b_2 \ln S + b_3 \ln y$$

$$\ln(S) = \ln d_0 + d_1 \ln p_s + d_2 \ln C + d_3 \ln y$$

For income, sales tax receipts were used. The seasonal variable used is precipitation (primarily because rainfall is relatively great in Western Washington).

For the variables q, C, and S, we have used the detail available in terms of the numbers of households selecting a particular service. Therefore, the monthly quantity variable is in terms of tons per household. For measures of the number of cans chosen and service level selected, we use the "odds" of choosing more than the basic level offered. That is, for cans, we use the odds of choosing more than one can of service which is the ratio of the number of households choosing two or more cans of service to the number choosing one can. Similarly for location, we use the ratio of the number of households choosing more than "curb" service to the number choosing the basic curbside service.

Using two-stage least squares, the resulting estimates are:

$$\ln(q) = -5.5 + \underset{(.93)}{.85}\ \ln C - \underset{(.77)}{.34}\ \ln S + \underset{(.22)}{.23}\ \ln y - \underset{(.003)}{.0002}\mathrm{PRECIP} \tag{67}$$

$$\ln(C) = 3.2 - \underset{(.11)}{.12}\ \ln p_c - \underset{(.13)}{.06}\ \ln y + \underset{(.42)}{.41}\ \ln(q) + \underset{(.12)}{.61}\ \ln S \tag{68}$$

$$\ln(S) = -5.9 + \underset{(.15)}{.09}\ \ln p_s + \underset{(.41)}{1.76}\ \ln C + \underset{(.30)}{.13}\ \ln y + \underset{(.97)}{.87}\ \ln q \tag{69}$$

As can be seen, the only significant explanatory variables are between the levels of service chosen.

Since precipitation was not significant and because the dummy variable representing the winter months appears to be important in many of the other case studies, we next substitute the dummy variable for winter for the precipitation variable. In addition we add to the waste generation equation the variables for the number of extra bags (EXT) and the amount of waste self-hauled (SELF). The results, again applying two-stage least squares, are

$$\ln(q) = -2.88 + \underset{(.86)}{1.0}\ \ln C - \underset{(.76)}{.42}\ \ln(S) - \underset{(.21)}{.02}\ \ln y - \underset{(.04)}{.08}\ \mathrm{WIN} \tag{70}$$

$$+ \underset{(5.3 \times 10^{-6})}{2.7 \times 10^{-6}}\ \mathrm{EXT} + \underset{(1.3 \times 10^{-8})}{9.9 \times 10^{-9}}\ \mathrm{SELF}$$

$$\ln(C) = 2.3 - \underset{(.05)}{.18} \ln p_c - \underset{(.06)}{.004} \ln(y) + \underset{(.08)}{.08} \ln(q) + \underset{(.05)}{.72} \ln(S) \qquad (71)$$

$$\ln(S) = -3.1 + \underset{(.06)}{.15} \ln(p_s) - \underset{(.10)}{.0002} \ln(y) - \underset{(.13)}{.14} \ln(q) + \underset{(.13)}{1.5} \ln(C) \qquad (72)$$

The results of these regressions are interesting. Looking at Equation (71) we see that there is a negative and significant price elasticity of .18. That is, for every 10% increase in incremental can price, the percentage of households choosing more than one can of service falls by 1.8%. However, from equation (70) it appears that waste generation per household is not significantly related to the percentage of households choosing more than one can of service. If true, this would suggest that the way people respond to increases in the incremental price of containers is by demanding fewer containers and using those demanded more intensively. The price elasticity for location is, however, positive and significant, suggesting specification error.

A second approach to testing for the existence of negative and statistically significant price elasticities is to derive the reduced form equation for waste collected and to use OLS. The reduced form (excluding SELF and EXT) can be shown to be:

$$q = a_0' \, p_s^{a_1'} \, p_c^{a_2'} \, y^{a_3'} \, \mathrm{WIN}^{a_4'} \qquad (73)$$

When OLS is applied to the logs of (13), the result is:

$$\ln(q) = -2.3 - \underset{(.26)}{.47} \ln p_s + \underset{(.49)}{.59} \ln p_c + \underset{(.18)}{.01} \ln y - \underset{(.03)}{.10} \mathrm{WIN}$$

$R^2 = .43$

$N = 41$

Neither the coefficients on the price of an incremental can nor on location are significant at the 95% level.

Because the prices on containers and location are set by the same authority and change at the same time, it might be suspected that the coefficient estimates are inefficient (but not unbiased) because of multicollinearity. However, the two terms are not perfectly correlated. To regress quantity disposed on one of the prices (either container or location) would result in specification error. Further, the exact form of specification error would be one of omitted variables and the omitted variable would be positively related to the included variable(s). Therefore, the coefficient estimated for the included variable would be biased away from zero.

LITTER AND ADMINISTRATIVE COSTS

Litter and Resource Recovery

As in other cities studied, we found no evidence to support the hypothesis that imposition of user charges or an increase in price of collection leads to increased littering or other forms of disposal with excessive social costs. The use of a proxy variable for quantity of litter, or to put it another way, the lack of data on quantity of litter, means that this hypothesis has not been directly tested. On the other hand, experience of solid waste personnel corroborates the view that littering has not increased. Although it has been fifty years since litter was a serious problem, the problem arose on that occasion because collection service was non-mandatory. A similar situation occurred in 1973 in the recently annexed Hilltop district of northeast Tacoma. Refuse collection had not been mandatory, and illicit dumping took place in ravines in the district. Upon annexation, some residents (40%, according to one news report) opposed mandatory city collection, preferring to continue with private haulers. After a lengthy court battle, city collection was imposed and both illicit dumping and residents' opposition abated.

The presence of an easily accessible landfill where residents may dump rubbish at no charge could also be an important factor in preventing litter. At present the cost to the city of disposing of waste self-hauled by residents is subsidized jointly from all other revenue sources, as is the cost of collecting and disposing waste from other non-commercial, non-residential sources.

Tacoma has this year instituted a large scale resource recovery program which is expected eventually to recycle over 80% of the city's waste stream and to finance itself from sale of recycled material. At the same time, we found no evidence of either volunteer or commercial resource recovery ventures for household waste. Whether this program will meet expectations remains to be seen, but it is worth noting that in this case the user charge system has not led to residents participating directly in resource recovery operations on such a scale, and that the incentive for developing the program has mainly to do with availability of large-scale recovery technology and federal grants on the one hand, and problems with disposal (lack of landfill sites), as opposed to collection, on the other.

Administrative Costs

During the six years for which annual reports are available, revenues from residential user charges were on average 9% more than total collection costs for collected household waste and 4% less than combined collection and disposal costs. Thus costs and revenues from household waste appear to be closely matched. Billing costs average 3.4% of revenue over the same period, a figure close to the national average reported in the 1976 Columbia study [13]. Historically, the Refuse Utility has been self-supporting throughout its history and it has had to pay the same state and local taxes that a private hauler would under any other service arrangement. This has been achieved without major cross-subsidies between commercial customers, residential customers, and private haulers outside Tacoma who use the city landfill, and prices are said to be comparable with those elsewhere in the region. Thus the Refuse Utilty seems to have met all criteria for allocative efficiency of solid waste services.

It is sometimes argued that user charges facilitate management techniques such as careful cost accounting, and there is no evidence from Tacoma which would contradict this.

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APPENDIX A

LIST OF USER FEE CITIES

The list of cities employing user fees was compiled from secondary sources, particularly national or regional surveys of solid waste collection practices. These surveys are not strictly comparable, and there are problems with the reliability of each. Therefore, the combined list should not be considered complete, representative, or even, perhaps, accurate. It is, however, the most extensive list of user fee cities in existence, and it has at least the merit of reconciling many contradictions which have appeared elsewhere.

Most cities in the list have been derived from observations contained in a 1975 Columbia University survey and American Public Works Association surveys of 1964 and 1973. These are described in detail in The Organization and Efficiency of Solid Waste Collection, E.S. Savas, ed., 1977, and Solid Waste Collection Practices, 4th edition, APWA, 1975. Michael Traugott of the Inter-University Consortium for Political and Social Research provided us with a complete listing of all cities from the Columbia study where respondents indicated household collections were paid for through user charges (universal telephone survey, question IIIA, response 4, 5, 6, or 7). The Institute for Solid Waste, APWA, kindly allowed us to inspect questionnaires returned in the 1973 survey, which asked respondents whether residential collection was financed through user fees, taxes, or a combination of both, as well as asking them to provide a price schedule for collection service. Additional APWA survey information was taken from tables appearing in Solid Waste Collection Practices and in "Waste Collection Services: Cost and Pricing" by Stephen L. Feldman, from Public Prices for Public Products, Mushkin, ed., 1972.

Two other published sources were used to compile the list: "Economics of Solid Waste Management" by J. M. McFarland, from Comprehensive Studies of Solid Wastes Management, 1972, contains a list of all cities in California which had municipal collection of solid waste in 1969; our list includes all such cities reported to have some form of user fee. The Economics of Refuse Collection by Kemper and Quigley, 1976, contains a list of some cities and towns in Connecticut with private refuse collection as of April 1974. Although Kemper and Quigley do not report specific empirical findings on types or bases of user fees throughout Connecticut, private collection entails a user fee by definition; hence these cities are included in our list.

Finally, in the course of selecting cities for case study we had occasion to communicate directly with local government officials in a number of cities during March 1978. These communications were in no sense a survey, but rather clarification and confirmation of information discovered elsewhere. This information is incorporated into our list. Also in connection with our case study selection, Mr. Oscar Albrecht of the Federal EPA provided us with a short list of cities which, according to his personal records, employ user fees.

All cities cited as having user fees by any of these sources appear in our list. When cities were cited by more than one source, only the references giving more explicit information appears; e.g., where a city was cited by two sources as having variable fees, but one source gave the fee basis and the other did not, only the former is listed as a reference. Consequently, where we list more than one source as a reference, each provided the same information about type and basis of fee. Where different sources provided conflicting information, the city name appears more than once, with conflicting data and their sources beside separate listings. Where our direct communications provided information that conflicted with other sources, however, information and source references at odds with our findings were omitted.

Conflicting information from different sources on the existence, type, and basis of user fees may be explained in a number of ways. First, cities may have changed from one system to another between the dates of various surveys. Little is known about how many cities have changed to or from user fee systems, and notions of why such changes occur are largely theoretical or speculative. Second, a city may of course have several haulers who charge according to different kinds of fee structures. And third, survey instruments may have been imprecise or ambiguous.

As an example of ambiguity, consider our experience with Provo, Utah, one of the cities where we conducted a case study. Published results of the 1973 APWA survey led us to believe Provo had a location-based variable user fee. When we first contacted officials in Provo they were uncertain as to what we meant by the term "user fee," but when we asked whether collection was financed out of taxes or paid directly by households, our meaning became clear. When we further asked whether there was a flat fee or variable fee, we were told there was a flat fee. Since this was at odds with the APWA report, we probed further, asking whether customers were charged different rates for backyard and curbside collection. There was, we were told, a flat fee for the former and a different flat fee for the latter. Because terms like "variable fee" and "user charge" are technical, it is easy to see how the Columbia survey question could have been misunderstood -- Provo does indeed have a flat fee user charge for everyone getting the same level of service. Subsequent questions in the Columbia survey might have clarified this conceptual error, but evidently they did not. This may also account for why two other cities where we conducted case studies -- Tacoma and Sacramento -- were erroneously reported by the Columbia study to have flat fee user charges.

Conflicts between the two national surveys (Columbia and APWA) indicate error in one or both. We found 95 cities listed by both surveys as having user fees. Of these, there were 44 instances where one or both surveys either failed to indicate the type of fee used (flat or variable) or else one or both surveys presented self-contradictory information. Of the remaining 51 cities, there were 27 cases where both surveys indicated the city to have a flat fee, and 14 cases where the two surveys obtained opposing results. Assuming both surveys were equally prone to err, an error rate of about 16.5% is indicated. If a similar rate of error occurred in determining which cities had user fees and which did not, then more than 150 of the cities we have listed do not in fact have user fees. However, because the sampling universe of the surveys differs, and because we do not have a full list of cities examined in both surveys, it is difficult to pursue this point meaningfully.

No national or regional survey of solid waste collection systems has ever systematically investigated the full variety of user fee systems currently practiced. For Quigley and Kemper, information on user fee systems was incidental to the main thrust of research. McFarland considers only cities in California with Municipal collection, which are a minority in that state. The APWA surveys have been distinguished by collecting data on fee structures in all their complexity, but these data have been presented only in illustrative form, and the surveys have been troubled by low response rates. The Columbia survey proceeds far more systematically and has therefore provided a basis for some useful statistical conclusions, but its sampling universe was restricted and there is prima facie evidence of observational error in particular cases. Two obstacles seem especially important in all of these efforts: the difficulty of obtaining detailed price data from private haulers, and the lack of generally accepted nomenclature for survey use. For all of these reasons, it would seem that a complete or representative list of cities employing user fees must await further research.

USER FEE CITY LIST

LEGEND:

TYPE:
F = flat fee
V = variable fee
U = unknown

BASIS (for variable fee):
C = container
Q = quantity (metered bag)
L = location of pickup
F = frequency of collection
U = unknown

REFERENCES:
1 = phone conversation
2 = EPA (MERL - Cincinnati)
3 = APWA survey, 1973, transcription from raw data
4 = APWA survey, 1973, published results
5 = APWA survey, 1964, published results
6 = Columbia University survey, 1975, computer listing
7 = J. M. McFarland, 1971 California survey, pp. 45-48
8 = Kemper and Quigley, 1975 Connecticut study, p. 164

N.B. Cities listed more than once indicate conflicting references.

TABLE A-1. CITIES EMPLOYING USER FEES FOR HOUSEHOLD SOLID WASTE COLLECTION

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
ALABAMA				
AUBURN	ALB	U		3
CHICKASAW	ALB	F		6
FOLEY	ALB	F		6
FULTONDALE	ALB	F		6
GLENCOE	ALB	F		6
HUNTSVILLE	ALB	U		3
LEEDS	ALB	F		6
MADISON	ALB	F		6
MONTGOMERY	ALB	F		6
MOUNTAIN BROOK	ALB	F		6
MOUNTAIN BROOK	ALB	V	U	6
ROOSEVELT	ALB	V	U	6
TUSCALOOSA	ALB	F		6
VESTAVIA HILLS	ALB	V	U	6
VESTIVIA HILLS	ALB	F		6
WETUMPKA	ALB	F		6
ALASKA				
FAIRBANKS	ALS	V	C	4
ARIZONA				
AVONDALE	ARI	F		6
BUCKEYE	ARI	V	U	6
CHANDLER	ARI	F		6
MESA	ARI	F		3,6
PARADISE VALLEY	ARI	V	U	6
PARKER	ARI	F		3
PEORIA	ARI	F		6
TEMPE	ARI	F		6
WICKENBURG	ARI	F		6
ARKANSAS				
BENTON	ARK	V	U	6
CAMDEN	ARK	F		5
EL DORADO	ARK	F		3
JACKSONVILLE	ARK	F		6
LITTLE ROCK	ARK	F		5,6
NORTH LITTLE ROCK	ARK	F		3,6
PINE BLUFF	ARK	F		6
SHERWOOD	ARK	F		6
CALIFORNIA				
ALAMEDA COUNTY	CAL	F		3
ALHAMBRA	CAL	F		5
ANAHEIM	CAL	F		6
ANTIOCH	CAL	V	C,F	4
ARVIN	CAL	F		6
AUBURN	CAL	V	U	6
BANNING	CAL	U		7
BARSTOW	CAL	V	N	6
BEAUMONT	CAL	U		7
BENICIA	CAL	V	N	6
BERKELEY	CAL	V	C,L	1
BLYTHE	CAL	F		7

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
BRAWLEY	CAL	U		7
BREA	CAL	F		6
BUENA PARK	CAL	F		3
BURBANK	CAL	F		1,3,4,5
BURLINGAME	CAL	U		3
CALEXICO	CAL	U		7
CAMPBELL	CAL	V	U	6
CARLSBAD	CAL	F		6
CERES	CAL	F		6
CHOWCHILLA	CAL	U		7
CHULA VISTA	CAL	F		3
CHULA VISTA	CAL	V	U	6
CLAREMONT	CAL	U		7
CLOVERDALE	CAL	V	U	6
CLOVIS	CAL	F		6
COACHELLA	CAL	F		6,7
COALINGA	CAL	F		6
COLTON	CAL	F		6
COLUSA	CAL	U		7
COMPTON	CAL	V	C	3
COMPTON	CAL	F		5
CONCORD	CAL	V	C	4
CORCORAN	CAL	U		7
CORONA	CAL	F		6
COSTA MESA	CAL	U		3
COVINA	CAL	F		1,3
CYPRESS	CAL	F		3
CYPRESS	CAL	V	U	6
DALY CITY	CAL	F		3
DAVIS	CAL	V	C	3
DEL MAR	CAL	F		6
DELANO	CAL	F		6,7
DINUBA	CAL	V	C	4
DIXON	CAL	F		7
DOS PALOS	CAL	U		7
DUNSMUIR	CAL	U		7
EL CAJON	CAL	V	U	6
EL CERRITO	CAL	V	C	3
EL MONTE	CAL	F		3
ELSINORE	CAL	F		6
ELSINORE	CAL	V	U	6
ESCONDIDO	CAL	F		3,6
EXETER	CAL	U		7
FAIRFIELD	CAL	V	U	6
FARMERSVILLE	CAL	U		7
FILLMORE	CAL	V	U	6
FIREBAUGH	CAL	V	U	6
FOLSOM	CAL	F		6
FOUNTAIN VALLEY	CAL	F		6
FRESNO	CAL	F		1,6
FULLERTON	CAL	U		3

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
GALT	CAL	F		6
GILROY	CAL	F		6
GLENDALE	CAL	F		3
GONZALES	CAL	F		6
GUADALUPE	CAL	V	U	6
GUSTINE	CAL	F		7
HANFORD	CAL	F		7
HAYWARD	CAL	U		3
HEMET	CAL	U		7
HOLLISTER	CAL	U		7
HOLTVILLE	CAL	U		7
HUNTINGTON PARK	CAL	V	C	7
HURON	CAL	U		7
IMPERIAL BEACH	CAL	F		3,6
INGLEWOOD	CAL	U		3,7
KERMAN	CAL	F		6
KING CITY	CAL	V	U	6
KINGSBURG	CAL	F		6
LA MESA	CAL	F		3
LA MESA	CAL	V	U	6
LAGUNA BEACH	CAL	F		6
LEMOORE	CAL	U		7
LINCOLN	CAL	F		6
LINDSAY	CAL	U		7
LIVINGSTON	CAL	U		7
LOMPOC	CAL	F		3
LONG BEACH	CAL	V	C	7
LOS ALAMITOS	CAL	V	U	6
LOS ALTOS	CAL	V	C	3
LOS GATOS	CAL	V	U	6
LUKEPORT	CAL	U		2
LYNNWOOD	CAL	F		3,4
MADERA	CAL	U		7
MANHATTAN BEACH	CAL	F		3
MANTECA	CAL	F		6
MARIN COUNTY	CAL	V	C,F	4
MCFARLAND	CAL	V	U	6
MENDOTA	CAL	F		6
MERCED	CAL	U		7
MILPITAS	CAL	F		6
MODESTO	CAL	V	U	6
MONTCLAIR	CAL	F		6
MONTEREY	CAL	V	U	6
MONTEREY PARK	CAL	F		3
MOORHEAD	CAL	F		3
NAPA	CAL	V	U	6
NATIONAL CITY	CAL	V	U	6
NEEDLES	CAL	U		7
NEWARK	CAL	U		3
NEWMAN	CAL	F		6
NORWALK BEACH	CAL	F		3

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
NOVATO	CAL	U		3
OAKLAND	CAL	V	C,F	3
OCEANSIDE	CAL	F		6
ONTARIO	CAL	F		3,6,7
ORANGE	CAL	F		6
ORANGE COVE	CAL	F		6
OXNARD	CAL	F		4,6
PACIFIC GROVE	CAL	V	U	6
PACIFICA	CAL	U		3
PALM SPRINGS	CAL	F		7
PALM SPRINGS	CAL	V	U	6
PALO ALTO	CAL	F		6
PARLIER	CAL	F		7
PASADENA	CAL	F		3,7
PATTERSON	CAL	U		7
PERRIS	CAL	F		6
PETALUMA	CAL	V	U	6
PICO RIVERA	CAL	U		3
POMONA	CAL	F		5
PORTERVILLE	CAL	U		7
REDDING	CAL	F		7
REDLANDS	CAL	F		7
REDONDO BEACH	CAL	U		7
REEDLEY	CAL	F		6
RIALTO	CAL	F		6
RIO VISTA	CAL	V	U	6
RIVERSIDE	CAL	F		6
RIVERSIDE	CAL	V	U	6
ROCKLIN	CAL	V	U	6
ROSEVILLE	CAL	F		6
SACRAMENTO	CAL	V	C	1
SALINAS	CAL	V	C	3
SAN BERNADINO	CAL	F		6,7
SAN DIEGO COUNTY	CAL	U		3
SAN FERNANDO	CAL	F		7
SAN FRANCISCO	CAL	U		3,4
SAN JACINTO	CAL	F		6,7
SAN JOAQUIN	CAL	U		7
SAN JOSE	CAL	V	U	6
SAN JUAN BAUTISTA	CAL	U		7
SAN JUAN CAPISTRANO	CAL	V	U	6
SAN LEANDRO	CAL	U		3
SAN MARCOS	CAL	V	U	6
SANGER	CAL	F		6,7
SANTA ANA	CAL	F		4,6
SANTA BARBARA	CAL	V	U	6
SANTA BARBARA COUNTY	CAL	U		3
SANTA CLARA	CAL	V	C	3,5
SANTA CLARA	CAL	F		6
SANTA CRUZ	CAL	U		3,7
SANTA MARIA	CAL	V	C,L	1,4

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
SANTA MONICA	CAL	F		1
SANTA PAULA	CAL	F		6
SANTA ROSA	CAL	V	U	6
SARATOGA	CAL	V	U	6
SEAL BEACH	CAL	F		6
SEASIDE	CAL	V	U	6
SELMA	CAL	V	U	6
SHAFTER	CAL	U		7
SIGNAL HILL	CAL	U		7
SONOMA	CAL	V	U	6
STANTON	CAL	V	U	6
STOCKTON	CAL	V	U	6
SUNNYVALE	CAL	U		3
TAFT	CAL	F		6
TEHACHAPI	CAL	F		6
THOUSAND OAKS	CAL	V	U	6
TORRANCE	CAL	F		3,7
TULARE	CAL	V	U	7
TULELAKE	CAL	U		7
TURLOCK	CAL	F		6
UPLAND	CAL	F		6
VALLEJO	CAL	V	C,L	1
VENTURA	CAL	V	U	6
VILLA PARK	CAL	V	U	6
VISALIA	CAL	F		3,8
VISTA	CAL	V	U	6
WASCO	CAL	F		7
WATSONVILLE	CAL	U		7
WEED	CAL	F		7
WESTMORELAND	CAL	U		7
WHITTIER	CAL	U		3
WILLIAMS	CAL	U		7
WINTERS	CAL	F		7
WOODLAND	CAL	F		6
YORBA LINDA	CAL	V	U	6
COLORADO				
ARVADA	COL	U		3
BOULDER	COL	V	U	6
CHERRY HILLS VILLAGE	COL	V	U	6
COLORADO SPRINGS	COL	V	U	6
DURANGO	COL	V	C	3
FORT COLLINS	COL	F		5
GRAND JUNCTION	COL	F		3
GREENWOOD VILLAGE	COL	V	U	6
LAFAYETTE	COL	V	U	6
LOVELAND	COL	U		3
MANITOU SPRINGS	COL	V	U	6
PUEBLO	COL	V	U	6
SHERIDAN	COL	V	U	6
STERLING	COL	V	C	5
WHEAT RIDGE	COL	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
CONNECTICUT				
ANDOVER	CON	U		8
AVON	CON	U		8
BETHANY	CON	V	U	6
BETHEL	CON	V	U	6
BOLTON	CON	U		8
BOZRAH	CON	U		8
BRIDGEWATER	CON	U		8
BROOKFIELD	CON	U		8
BURLINGTON	CON	U		8
CANTON	CON	U		8
CHAPLIN	CON	U		8
CHESHIRE	CON	V	U	6
CLINTON	CON	U		8
CORNWALL	CON	U		8
CROMWELL	CON	U		8
DANBURY	CON	V	U	6
DARIEN	CON	U		8
EAST WINDSOR	CON	U		8
EASTON	CON	V	U	6
FAIRFIELD	CON	U		8
FARMINGTON	CON	F		6
FRANKLIN	CON	U		8
GLASTONBURY	CON	U		8
GRANBY	CON	U		8
GREENWICH	CON	V	U	6
GRISWOLD	CON	V	U	6
GROTON	CON	V	U	6
GUILFORD	CON	V	U	6
HARWINTON	CON	U		8
HEBRON	CON	U		8
KILLINGLY	CON	U		8
LEBANON	CON	U		8
LEDYARD	CON	U		8
LISBON	CON	V	U	6
LITCHFIELD	CON	U		8
MANSFIELD	CON	U		8
MERIDEN	CON	V	U	6
MIDDLEBURY	CON	V	U	6
MIDDLETOWN	CON	U		8
MONROE	CON	V	U	6
MONTVILLE	CON	U		8
MORRIS	CON	U		8
NEW CANAAN	CON	U		8
NEW MILFORD	CON	U		8
NEWTOWN	CON	U		8
NORTH BRANFORD	CON	V	U	6
NORWALK	CON	V	U	6
NORWICH	CON	F		3,6
NORWICH	CON	V	U	6
ORANGE TOWN	CON	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
PLYMOUTH	CON	U		8
PROSPECT	CON	V	U	6
REDDING	CON	U		8
SHARON	CON	U		8
SIMSBURY	CON	U		8
SOMERS	CON	U		8
SOUTH WINDSOR	CON	U		8
SOUTHINGTON	CON	U		8
SPRAGUE	CON	V	U	6
STAMFORD	CON	V	U	6
STRATFORD	CON	V	U	6
THOMASTON	CON	V	U	6
TRUMBULL	CON	V	L	3
WARREN	CON	U		8
WATERTOWN	CON	V	U	6
WESTBROOK	CON	U		8
WESTPORT	CON	V	U	6
WILTON	CON	U		8
WINDHAM	CON	U		8
WOODBRIDGE	CON	V	U	6
WOODBURY	CON	V	U	6
DELAWARE				
WILMINGTON	DEL	U		3
FLORIDA				
APOPKA	FLO	F		6
BELLE GLADE	FLO	F		6
BELLE ISLE	FLO	V	U	6
BISCAYNE PARK	FLO	F		6
BOCA RATON	FLO	F		6
BOYNTON BEACH	FLO	F		6
CORAL GABLES	FLO	F		6
DANIA	FLO	V	U	6
DAVIE	FLO	V	U	6
DAYTONA BEACH	FLO	F		4
DELRAY BEACH	FLO	F		6
DELRAY BEACH	FLO	V	U	6
DUNEDIN	FLO	F		6
FLORIDA CITY	FLO	F		6
FORT LAUDERDALE	FLO	F		4, 6
FORT PIERCE	FLO	F		3
GAINESVILLE	FLO	F		6
GULF BREEZE	FLO	F		6
GULFPORT	FLO	F		6
HOLLYWOOD	FLO	F		3, 6
HOMESTEAD	FLO	F		6
INDIAN ROCKS BEACH	FLO	V	U	6
JACKSONVILLE	FLO	F		3
JUPITER	FLO	F		6
KEY WEST	FLO	F		3
KISSIMMEE	FLO	U		2
LANTANA	FLO	F		6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
LIGHTHOUSE POINT	FLO	V	U	6
LONGWOOD	FLO	V	U	6
MADEIRA	FLO	F		6
MADEIRA BEACH	FLO	F		6
MARGATE	FLO	V	U	6
MELBOURNE	FLO	U		3
MIAMI BEACH	FLO	F		6
MIAMI SHORES	FLO	F		6
MIAMI SPRINGS	FLO	F		6
MILTON	FLO	F		6
NORTH BAY	FLO	F		6
NORTH MIAMI	FLO	F		6
NORTH MIAMI BEACH	FLO	F		6
NORTH PALM BEACH	FLO	F		6
OAKLAND PARK	FLO	F		6
OPA-LOCKA	FLO	F		6
ORLANDO	FLO	F		3,6
PAHOKEE	FLO	F		6
PANAMA CITY	FLO	F		3
PEMBROKE PARK	FLO	V	U	6
PEMBROKE PINES	FLO	F		6
PENSACOLA	FLO	F		1,3
PLANT CITY	FLO	F		6
PLANTATION	FLO	V	Q	1
RIVIERA BEACH	FLO	F		6
SAFETY HARBOR	FLO	F		6
SARASOTA	FLO	U		3
SOUTH BAY	FLO	F		6
SOUTH MIAMI	FLO	F		6
ST AUGUSTINE	FLO	F		3
ST PETERSBURG	FLO	V	C	4,5
ST PETERSBURG	FLO	F		6
ST PETERSBURG	FLO	V	U	6
SURFSIDE	FLO	F		6
SWEETWATER	FLO	F		6
TALLAHASSEE	FLO	F		6
TAMPA	FLO	F		4,6
TARPON SPRINGS	FLO	F		6
TEMPLE TERRACE	FLO	F		6
TREASURE ISLAND	FLO	F		6
WEST PALM BEACH	FLO	F		3,6
WILTON MANORS	FLO	V	U	6
WINTER PARK	FLO	F		3,6
GEORGIA				
ALBANY	GEO	F		3
ATLANTA	GEO	F		6
AUSTELL	GEO	F		6
AUSTELL	GEO	V	U	6
BUFORD	GEO	F		6
DECATUR	GEO	F		3
DORAVILLE	GEO	F		6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
EAST POINT	GEO	F		6
FAIRBURN	GEO	F		6
FOREST PARK	GEO	F		6
GAINESVILLE	GEO	U		3
GARDEN CITY	GEO	F		6
JONESBORO	GEO	F		6
KENNESAW	GEO	F		6
LAWRENCEVILLE	GEO	F		6
MACON	GEO	F		3, 6
MARIETTA	GEO	F		1,6
MORROW	GEO	V	U	6
PERRY	GEO	F		6
POWDER SPRINGS	GEO	F		6
RIVERDALE	GEO	F		6
ROSWELL	GEO	F		6
SMYRNA	GEO	F		6
THUNDERBOLT	GEO	V	U	6
IDAHO				
BOISE CITY	IDA	V	C	3
IDAHO FALLS	IDA	F		3
MERIDIAN	IDA	F		6
TWIN FALLS	IDA	F		3
ILLINOIS				
ARLINGTON HEIGHTS	ILL	F		3
BARTONVILLE	ILL	V	U	6
BELLWOOD	ILL	U		2
CARBONDALE	ILL	F		3
CHAMPAIGN	ILL	V	U	6
DECATUR	ILL	V	U	6
DES PLAINES	ILL	F		3,4
DOWNERS GROVE	ILL	F		3
ELMHURST	ILL	F		3
GLEN ELLYN	ILL	U		2
GLENVIEW	ILL	F		3
MARQUETTE HEIGHTS	ILL	V	U	6
MASON CITY	ILL	F		3
NORMAL	ILL	F		3,6
NORTHBROOK	ILL	V	F	3
OAK LAWN	ILL	V	C	4
PEKIN	ILL	V	L	3
PEKIN	ILL	F		6
RANTOUL	ILL	U		3
ROLLING MEADOWS	ILL	U		2
SPRINGFIELD	ILL	F		5
URBANA	ILL	V	U	6
WASHINGTON	ILL	V	U	6
WINNETKA	ILL	U		4
WOOD RIVER	ILL	U		3
ZION	ILL	F		3
INDIANA				
BROWNSBURG	IND	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
CHESTERFIELD	IND	V	U	6
DANVILLE	IND	V	U	6
ELWOOD	IND	V	U	6
INDIANAPOLIS	IND	V	U	6
JACKSON	IND	F		3
MOORESVILLE	IND	V	U	6
MUNCIE	IND	V	U	6
NEW HAVEN	IND	V	U	6
NEW WHITELAND	IND	V	U	6
PLYMOUTH	IND	V	U	6
SOUTH BEND	IND	F		4
SOUTH BEND	IND	V	U	6
IOWA				
AMES	IOW	U		3
CEDAR FALLS	IOW	F		3,4
DES MOINES	IOW	F		3
DUBUQUE	IOW	F		1,6
ESTHERVILLE	IOW	V	U	4
MARION	IOW	F		6
OTTUMWA	IOW	V	C	4
PERRY	IOW	F		5
SIOUX CITY	IOW	F		3
WAVERLY	IOW	F		3
WINDSOR HEIGHTS	IOW	V	U	6
KANSAS				
AUGUSTA	KAN	F		6
DERBY	KAN	V	U	6
EL DORADO	KAN	F		3,4,6
EMPORIA	KAN	U		3
HAYSVILLE	KAN	V	U	6
HUTCHINSON	KAN	V	C	4
LAWRENCE	KAN	F		3
LEAVENWORTH	KAN	U		3
OVERLAND PARK	KAN	U		3
PRAIRIE VILLAGE	KAN	U		3
SALINA	KAN	F		5
TOPEKA	KAN	F		3,6
TOPEKA	KAN	V	U	6
VALLEY CENTER	KAN	V	U	6
WICHITA	KAN	V	C	1,4
WICHITA	KAN	F		6
WICHITA	KAN	V	U	6
KENTUCKY				
HAZARD	KEN	U		3
OWENSBORO	KEN	F		6
PADUCAH	KEN	V	F	1,5
LOUISIANA				
BATON ROUGE	LOU	V	U	6
HARAHAN	LOU	F		6
LAFAYETTE	LOU	F		6
MONROE	LOU	F		5

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
VENTON	LOU	F		6
WESTLAKE	LOU	F		6
MAINE				
FALMOUTH	MAI	V	U	6
GORHAM	MAI	V	U	6
LISBON	MAI	V	U	6
SCARBOROUGH	MAI	U		3
MARYLAND				
COLLEGE PARK	MAR	F		4
COLUMBIA	MAR	V	U	4
ROCKVILLE	MAR	F		3
SALISBURY	MAR	U		3
TOWSON	MAR	U		3
MASSACHUSETTS				
AMHERST	MAS	F		3
BILLERICA	MAS	V	U	6
BOYLSTON	MAS	V	U	6
DALTON	MAS	V	U	6
HANOVER	MAS	U		2
LEE	MAS	V	U	6
MILLBURY	MAS	V	U	6
NEEDHAM	MAS	U		3
NORTHBRIDGE	MAS	V	U	6
OXFORD	MAS	V	U	6
ROCKPORT	MAS	U		3
TEWKSBURY	MAS	F		6
UPTON	MAS	V	U	6
WELLESLEY	MAS	U		3
WELLESLEY HILLS	MAS	U		3
WEST BOYLSTON	MAS	V	U	6
WESTFORD	MAS	V	U	6
MICHIGAN				
ADA	MIC	V	U	6
ALPINE	MIC	V	U	6
ANN ARBOR TOWNSHIP	MIC	V	U	6
ARGENTINE TOWNSHIP	MIC	V	U	6
ATTICA TOWNSHIP	MIC	V	U	6
BANGOR TOWNSHIP	MIC	V	U	6
BATTLE CREEK	MIC	U		3
CALEDONIA	MIC	V	U	6
CARROLLTON	MIC	F		6
CASCADE	MIC	V	U	6
CHARLOTTE	MIC	V	U	6
CHELSEA	MIC	V	U	6
CLAYTON TOWNSHIP	MIC	V	U	6
COMSTOCK	MIC	V	U	6
DALTON	MIC	V	U	6
DE WITT	MIC	V	U	6
DEERFIELD TOWNSHIP	MIC	V	U	6
EATON RAPIDS	MIC	V	U	6
ELBA TOWNSHIP	MIC	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
FLINT TOWNSHIP	MIC	V	U	6
FOREST	MIC	V	U	6
FRANKENMUTH	MIC	F		6
FRUITLAND TOWNSHIP	MIC	V	U	6
GAINES	MIC	V	U	6
GEORGETOWN	MIC	V	U	6
GRAND HAVEN	MIC	V	U	6
GRAND RAPIDS	MIC	V	Q	1
HAMPTON TOWNSHIP	MIC	V	U	6
HOLLAND	MIC	V	U	6
JAMESTOWN	MIC	V	U	6
KALAMAZOO	MIC	V	U	6
KENTWOOD	MIC	V	U	6
LAKETON TOWNSHIP	MIC	V	U	6
LANSING	MIC	F		6
LANSING	MIC	V	U	6
LAPEER	MIC	V	U	6
LAPEER TOWNSHIP	MIC	V	U	6
MAYFIELD TOWNSHIP	MIC	V	U	6
MERIDIAN	MIC	V	U	6
MONITOR TOWNSHIP	MIC	V	U	6
MONTROSE	MIC	V	U	6
MOUNT CLEMENS	MIC	F		3
NORTH MUSKEGON	MIC	V	U	6
NORTHFIELD	MIC	V	U	6
OREGON TOWNSHIP	MIC	V	U	6
OSHTEMO TOWNSHIP	MIC	V	U	6
PLAINFIELD	MIC	V	U	6
PORTAGE	MIC	V	U	6
PORTSMOUTH TOWNSHIP	MIC	V	U	6
RICHLAND TOWNSHIP	MIC	V	U	6
ROSS	MIC	V	U	6
SAGINAW	MIC	V	U	6
SAGINAW TOWNSHIP	MIC	V	U	6
SALEM TOWNSHIP	MIC	V	U	6
SCIO	MIC	V	U	6
SOUTHFIELD	MIC	F		3
SPARTA	MIC	V	U	6
SPRING LAKE	MIC	V	U	6
TALLMADGE	MIC	V	U	6
TEXAS TOWNSHIP	MIC	V	U	6
THETFORD TOWNSHIP	MIC	V	U	6
WILLIAMSTON	MIC	V	U	6
WYOMING	MIC	V	U	6
YORK TOWNSHIP	MIC	V	U	6
ZEELAND	MIC	V	U	6
MINNESOTA				
ANOKA	MIN	U		3
BLOOMINGTON	MIN	U		3
BROOKLYN CENTER	MIN	U		3
BROOKLYN PARK	MIN	F		3

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
COON RAPIDS	MIN	U		3
CRYSTAL	MIN	F		3
DULUTH	MIN	U		3
EDINA	MIN	U		3
FAIRBAULT	MIN	U		3
FRIDLEY	MIN	U		3
GOLDEN VALLEY	MIN	U		3
INVER HEIGHTS	MIN	U		2
MAPLEWOOD	MIN	U		3,4
MINNETONKA	MIN	F		3
ROCHESTER	MIN	V	U	6
SEDALIA	MIN	F		3
SOUTH ST PAUL	MIN	U		3
ST CLOUD	MIN	F		1
ST PAUL	MIN	F		3
STEWARTVILLE	MIN	V	U	6
WHITE BEAR LAKE	MIN	F		3
MISSOURI				
CENTRALIA	MRI	F		6
COLUMBIA	MRI	F		3, 6
FERGUSON	MRI	U		3
GLADSTONE	MRI	U		3
INDEPENDENCE	MRI	U		3
KANSAS CITY	MRI	U		2, 4
KIRKWOOD	MRI	F		3
NEVADA	MRI	U		3
POPLAR BLUFF	MRI	U		3
SPRINGFIELD	MRI	V	U	6
WEBSTER GROVES	MRI	U		3
MONTANA				
BILLINGS	MTA	V	L	1, 3
GREAT FALLS	MTA	F		6
GREAT FALLS	MTA	V	U	6
HELENA	MTA	F		3
NEBRAKA				
GRAND ISLAND	NEB	U		3
LINCOLN	NEB	V	U	6
SIDNEY	NEB	F		5
NEVADA				
BOULDER CITY	NED	F		6
HENDERSON	NED	F		6
LAS VEGAS	NED	V	U	6
LAS VEGAS	NED	F		4
RENO	NED	V	U	6
SPARKS	NED	U		3
NEW HAMPSHIRE				
HUDSON TOWN	NEH	V	U	6
LACONIA	NEH	U		3
NEW JERSEY				
EGG HARBOR TOWNSHIP	NEJ	V	U	6
HOHOKUS	NEJ	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
HOPEWELL TOWNSHIP	NEJ	V	U	6
MAPLEWOOD	NEJ	U		3
MONMOUTH JCT	NEJ	U		3
MULLICA TOWNSHIP	NEJ	V	U	6
OAKLAND	NEJ	V	U	6
PATERSON	NEJ	U		3
SOUTH ORANGE	NEJ	U		3
VINELAND	NEJ	V	U	6
WASHINGTON-BERGEN	NEJ	V	U	6
WYCKOFF	NEJ	V	U	6
NEW MEXICO				
ALBUQUERQUE	NEM	F		4,5,6
CARLSBAD	NEM	F		3
HOBBS	NEM	F		4
LOVINGTON	NEM	F		3
ROSWELL	NEM	F		3
NEW YORK				
AKRON	NEY	V	U	6
ALDEN	NEY	V	U	6
AMHERST	NEY	V	U	6
ARCADE	NEY	U		3
ARCADIA	NEY	V	U	6
AURORA	NEY	V	U	6
AVON	NEY	V	U	6
BALDWINSVILLE	NEY	V	U	6
BALLSTON SPA	NEY	V	U	6
BRIGHTON	NEY	V	U	6
BROCKPORT	NEY	V	U	6
CAMDEN	NEY	V	U	6
CAMILLUS	NEY	V	U	6
CARLTON TOWN	NEY	V	U	6
CAZENOVIA	NEY	V	U	6
CHARLTON TOWN	NEY	V	U	6
CHILI	NEY	V	U	6
CICERO	NEY	V	U	6
CLARKSTON	NEY	V	U	6
COLDEN	NEY	V	U	6
CONSTANTINA	NEY	V	U	6
CORINTH	NEY	V	U	6
DANSVILLE	NEY	V	U	6
DUANESBURG	NEY	V	U	6
EAST GREENBUSH TOWN	NEY	V	U	6
EDEN	NEY	V	U	6
ELBRIDGE	NEY	V	U	6
GATES	NEY	V	U	6
GLENVILLE	NEY	V	U	6
GRAND ISLAND	NEY	V	U	6
GRANDBY	NEY	V	U	6
GREECE TOWN	NEY	V	U	6
GREENFIELD TOWN	NEY	V	U	6
GROVELAND TOWN	NEY	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
HAMLIN TOWN	NEY	V	U	6
HENRIETTA TOWN	NEY	V	U	6
HOLLAND	NEY	V	U	6
HOOSICK	NEY	V	U	6
IRONDEQUOIT	NEY	V	U	6
LANCASTER	NEY	V	U	6
LEE TOWN	NEY	V	U	6
LENOX	NEY	V	U	6
LIVONIA	NEY	V	U	6
LYONS	NEY	V	U	6
LYSANDER	NEY	V	U	6
MACEDON	NEY	V	U	6
MALTA	NEY	V	U	6
MARCELLUS	NEY	V	U	6
MARION TOWN	NEY	V	U	6
MEXICO	NEY	V	U	6
MILTON	NEY	V	U	6
MOREAU	NEY	V	U	6
MOUNT MORRIS	NEY	V	U	6
NEWARK	NEY	V	U	6
NORTH GREENBUSH TOWN	NEY	V	U	6
OLD WESTBURY	NEY	U		3
OLEAN	NEY	P		3
ONTARIO TOWN	NEY	V	U	6
ORCHARD PARK	NEY	V	U	6
OSWEGO	NEY	V	U	6
PALMYRA	NEY	V	U	6
PARIS	NEY	V	U	6
PARMA	NEY	P		6
PATCHOGUE	NEY	P		3
PENFIELD TOWN	NEY	V	U	6
PERINTON	NEY	V	U	6
PITTSFORD	NEY	V	U	6
POESTENKILL TOWN	NEY	V	U	6
POMPEY	NEY	V	U	6
RAVENA	NEY	V	U	6
RIDGEWAY	NEY	V	U	6
RIGA	NEY	V	U	6
ROTTERDAM	NEY	V	U	6
SALINA	NEY	V	U	6
SAND LAKE	NEY	V	U	6
SCHODACK	NEY	V	U	6
SHELBY	NEY	V	U	6
SKANEATELES	NEY	V	U	6
SODUS	NEY	V	U	6
STILLWATER	NEY	V	U	6
SWEDEN	NEY	V	U	6
VERONA TOWN	NEY	V	U	6
VOORHEESVILLE	NEY	V	U	6
WALWORTH TOWN	NEY	V	U	6
WEBSTER	NEY	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
WEST MONROE	NEY	V	U	6
WESTMORELAND TOWN	NEY	V	U	6
WILLIAMSON	NEY	V	U	6
YORK TOWN	NEY	V	U	6
NORTH CAROLINA				
MONROE	NOC	F		6
WILMINGTON	NOC	F		6
WINSTON-SALEM	NOC	U		3
NORTH DAKOTA				
FARGO	NOD	U		8
GRAND FORKS	NOD	F		5
OHIO				
AKRON	OHI	F		6
AMHERST	OHI	V	U	6
AURORA	OHI	V	U	6
AUSTINTOWN	OHI	V	U	6
BAZETTA	OHI	V	U	6
BEAVER	OHI	V	U	6
BEAVER CREEK	OHI	V	U	6
BETHEL	OHI	V	U	6
BETHLEHEM	OHI	V	U	6
BLUFFTON	OHI	F		6
BOARDMAN	OHI	V	U	6
BRACEVILLE TOWNSHIP	OHI	V	U	6
BROOKFIELD	OHI	V	U	6
BUTLER	OHI	V	U	6
CANFIELD	OHI	V	U	6
CANTON	OHI	V	C	1,3
CENTERVILLE	OHI	F		6
CHAMPION TOWNSHIP	OHI	V	U	6
CLAY	OHI	V	U	6
CLINTON	OHI	V	U	6
COLUMBIA TOWNSHIP	OHI	V	U	6
COLUMBUS	OHI	F		3
CONCORD	OHI	V	U	6
COPLEY	OHI	V	U	6
CORTLAND	OHI	V	U	6
CUYAHOGA FALLS	OHI	F		6
CUYAHOGA FALLS	OHI	V	U	6
DELAWARE	OHI	U		3
ELYRIA	OHI	V	U	6
ENGLEWOOD	OHI	V	U	6
FAIRBORN	OHI	F		6
GERMAN	OHI	V	U	6
GERMANTOWN	OHI	F		6
GOSHEN TOWNSHIP	OHI	V	U	6
GREEN	OHI	V	U	6
GROVE CITY	OHI	V	U	6
HARRISON	OHI	F		6
HOWLAND	OHI	V	U	6
HUBBARD	OHI	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
HUDSON	OHI	V	U	6
KENT	OHI	V	U	6
KETTERING	OHI	U		3
LANIER	OHI	V	U	6
LEMON	OHI	V	U	6
LEXINGTON	OHI	V	U	6
LIBERTY	OHI	V	U	6
LIMA	OHI	F		6
LOUISVILLE	OHI	V	U	6
MACEDONIA	OHI	V	U	6
MAD RIVER	OHI	V	U	6
MADISON	OHI	V	U	6
MANSFIELD	OHI	F		1
MANTUA	OHI	V	U	6
MARION	OHI	V	U	6
MARLBORO TOWNSHIP	OHI	V	U	6
MAYWOOD	OHI	U		3
MCCOMB	OHI	V	Q	4
MENTOR	OHI	U		3
MILTON	OHI	V	U	6
MONROE	OHI	V	U	6
MOOREFIELD	OHI	V	U	6
MUNROE FALLS	OHI	V	U	6
NEW CARLISLE	OHI	V	U	6
NEW LEBANON	OHI	V	U	6
NEWBERRY	OHI	V	U	6
NEWTON	OHI	V	U	6
NEWTON FALLS	OHI	V	U	6
NILES	OHI	V	U	6
NORTH CANTON	OHI	F		6
NORTON	OHI	V	U	6
NORWALK	OHI	U		3
NORWICH	OHI	V	U	6
OSNABURG	OHI	V	U	6
PERRY	OHI	V	U	6
PERRY TOWNSHIP	OHI	V	U	6
PLEASANT	OHI	V	U	6
POLAND	OHI	V	U	6
RANDOLPH	OHI	V	U	6
RAVENNA	OHI	V	U	6
ROOTSTOWN	OHI	V	U	6
SCIOTO	OHI	V	U	6
SEBRING	OHI	V	U	6
SHARON	OHI	V	U	6
SHAWNEE	OHI	V	U	6
SHEFFIELD	OHI	V	U	6
SHEFFIELD LAKE	OHI	F		6
SHELBY	OHI	V	U	6
SILVER LAKE	OHI	V	U	6
SMITH	OHI	V	U	6
SOUTHINGTON TOWNSHIP	OHI	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
SPRINGFIELD	OHI	V	U	6
SPRINGFIELD TOWNSHIP	OHI	V	U	6
STOW	OHI	V	U	6
STREETSBORO	OHI	V	U	6
STRUTHERS	OHI	V	U	6
SUGAR CREEK	OHI	V	U	6
SUNBURY	OHI	V	U	6
TRENTON	OHI	F		6
TROTWOOD	OHI	F		6
TRURO	OHI	V	U	6
UNION	OHI	V	U	6
VAN WERT	OHI	V	U	6
VIENNA TOWNSHIP	OHI	V	U	6
WARREN	OHI	F		3,5,6
WARREN	OHI	V	U	6
WASHINGTON TOWNSHIP	OHI	V	U	6
WAYNE	OHI	V	U	6
WEATHERSFIELD	OHI	V	U	6
WESTERVILLE	OHI	F		6
WINDHAM	OHI	V	U	6
XENIA TOWNSHIP	OHI	V	U	6
OKLAHOMA				
BETHANY	OKL	F		6
BRISTOW	OKL	F		6
BROKEN ARROW	OKL	F		6
BROKEN ARROW	OKL	V	U	6
EDMOND	OKL	F		3,6
LAWTON	OKL	F		4
MIDWEST CITY	OKL	F		6
MIDWEST CITY	OKL	V	U	6
NICHOLS HILLS	OKL	F		6
NORMAN	OKL	F		3,6
OKLAHOMA CITY	OKL	F		5,6
OWASSO	OKL	F		6
SAPULPA	OKL	F		6
SHAWNEE	OKL	F		3,5
SKIATOOK	OKL	F		6
SPENCER	OKL	F		6
TULSA	OKL	F		6
TULSA	OKL	V	U	6
WARR ACRES	OKL	F		6
YUKON	OKL	F		6
OREGON				
ALBANY	ORE	U		3
ASTORIA	ORE	U		3
CORVALLIS	ORE	U		3
COTTAGE GROVE	ORE	V	U	6
DALLAS	ORE	V	U	6
EUGENE	ORE	V	C,F	3,5
MEDFORD	ORE	V	C	4
MONMOUTH	ORE	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
OAKRIDGE	ORE	F		6
OAKRIDGE	ORE	V	U	6
OREGON CITY	ORE	V	C	3
PORTLAND	ORE	U		3
SALEM	ORE	V	C	3
STAYTON	ORE	V	U	6
PENNSYLVANIA				
ADAMS	PEN	V	U	6
ALLEGHENY	PEN	V	U	6
ALSACE TOWNSHIP	PEN	V	U	6
ALTOONA	PEN	V	U	6
AMITY TOWNSHIP	PEN	V	U	6
ANTIS	PEN	V	U	6
BARNESBORO	PEN	F		6
BEAVER FALLS	PEN	F		3
BERN TOWNSHIP	PEN	F		6
BERN TOWNSHIP	PEN	V	U	6
BETHEL TOWNSHIP	PEN	V	U	6
BETHLEHEM	PEN	U		3
BIRDSBORO	PEN	V	U	6
BOYERTOWN	PEN	V	U	6
BRECKNOCK TOWNSHIP	PEN	V	U	6
BUTLER TOWNSHIP	PEN	V	U	6
CAMBRIA	PEN	V	U	6
CARLISLE	PEN	V	U	6
CODORUS TOWNSHIP	PEN	V	U	6
COLE BROOKDALE	PEN	V	U	6
CONEMAUGH	PEN	V	U	6
CONEWAGO	PEN	V	U	6
CUMRU	PEN	F		6
DALLAS	PEN	V	U	6
DALLAS TOWNSHIP	PEN	V	U	6
DOUGLASS TOWNSHIP	PEN	V	U	6
DUPONT	PEN	F		6
EAST COCALICO	PEN	V	U	6
EAST CONEMAUGH	PEN	F		6
EAST EARL TOWNSHIP	PEN	V	U	6
EAST HANOVER TOWNSHIP	PEN	V	U	6
EAST LAMPETER TOWNSHP	PEN	V	U	6
EAST TAYLOR	PEN	V	U	6
EASTON	PEN	F		3
EBENSBURG	PEN	V	U	6
ELIZABETHTOWN	PEN	V	U	6
EPHRATA TOWNSHIP	PEN	V	U	6
EXETER	PEN	V	U	6
FAIRVIEW TOWNSHIP	PEN	F		6
FAIRVIEW TOWNSHIP	PEN	V	U	6
FLEETWOOD	PEN	V	U	6
FORTY FORT	PEN	V	U	6
FOSTER	PEN	V	U	6
FRANKLIN	PEN	F		3

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
FRANKLIN TOWNSHIP	PEN	V	U	6
FREEDOM	PEN	V	U	6
FREELAND	PEN	F		6
FREELAND	PEN	V	U	6
GEISTOWN	PEN	F		6
GIRARD	PEN	F		6
GREENE TOWNSHIP	PEN	V	U	6
HAMPDEN	PEN	V	U	6
HARRISBURG	PEN	F		1, 6
HELLAM TOWNSHIP	PEN	V	U	6
HIGHSPIRE	PEN	F		6
HOLLIDAYSBURG	PEN	V	U	6
JACKSON	PEN	V	U	6
JENKINS TOWNSHIP	PEN	F		6
JENNER	PEN	V	U	6
JOHNSTOWN	PEN	F		6
KENHORST	PEN	F		6
KINGSTON	PEN	V	U	6
KUTZTOWN	PEN	F		6
LANCASTER	PEN	V	U	6
LITTLESTOWN	PEN	V	U	6
LONDONDERRY TOWNSHIP	PEN	V	U	6
LONGSWAMP TOWNSHIP	PEN	V	U	6
LOWER ALLEN	PEN	F		6
LOWER ALSACE TOWNSHIP	PEN	V	U	6
LOWER SAWARTA TOWNSHP	PEN	V	U	6
LOWER WINDSOR TOWNSHP	PEN	V	U	6
LOWER YODER	PEN	F		6
MANHEIM	PEN	V	U	6
MAXATAWNY TOWNSHIP	PEN	V	U	6
MEYERSDALE	PEN	V	U	6
MIDDLE PAXTON TOWNSHP	PEN	V	U	6
MIDDLESEX	PEN	V	U	6
MILLCREEK	PEN	V	U	6
MILLERSBURG	PEN	V	U	6
MOUNT JOY	PEN	F		6
MUHLENBERG TOWNSHIP	PEN	F		6
NANTICOKE	PEN	F		6
NANTY-GLO	PEN	V	U	6
NEW BRIGHTON	PEN	U		2
NEW CUMBERLAND	PEN	F		6
NEW HOLLAND	PEN	V	U	6
NEWBERRY TOWNSHIP	PEN	V	U	6
NEWTON TOWNSHIP	PEN	V	U	6
NORTH EAST TOWNSHIP	PEN	V	U	6
OIL CITY	PEN	F		3
OLEY TOWNSHIP	PEN	V	U	6
PAINT	PEN	F		6
PATTON	PEN	V	U	6
PENN	PEN	V	U	6
PENN TOWNSHIP	PEN	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
PITTSBURGH	PEN	P		3
PITTSTON	PEN	P		6
PLYMOUTH	PEN	P		6
PORTAGE	PEN	V	U	6
PROVIDENCE TOWNSHIP	PEN	V	U	6
READING	PEN	V	U	6
RICHLAND	PEN	V	U	6
RICHMOND TOWNSHIP	PEN	V	U	6
ROARING SPRING	PEN	V	U	6
ROBESON TOWNSHIP	PEN	V	U	6
SALISBURY	PEN	V	U	6
SHADE	PEN	V	U	6
SHADE TOWNSHIP	PEN	P		3
SHARON	PEN	P		3
SHIPPENSBURG	PEN	P		6
SHREWSBURY TOWNSHIP	PEN	V	U	6
SILVER SPRING TOWNSHP	PEN	V	U	6
SOMERSET	PEN	V	U	6
SOUTH HEIDELBERG TWSP	PEN	V	U	6
SOUTHMONT	PEN	P		6
SPANGLER	PEN	V	U	6
SPRING	PEN	V	U	6
STATE COLLEGE	PEN	P		3
STONYCREEK	PEN	P		6
STRABAN TOWNSHIP	PEN	V	U	6
SWATARA TOWNSHIP	PEN	V	U	6
TYRONE	PEN	V	U	6
UNION CITY	PEN	V	U	6
UPPER ALLEN	PEN	V	U	6
UPPER LEACOCK TOWNSHP	PEN	V	U	6
UPPER YODER	PEN	P		6
WARMINSTER	PEN	U		3
WEST COCALICO TOWNSHP	PEN	V	U	6
WEST EARL TOWNSHIP	PEN	V	U	6
WEST HANOVER	PEN	V	U	6
WEST LAMPETER TOWNSHP	PEN	V	U	6
WESTMONT	PEN	P		6
WINDBER	PEN	P		6
WORMLEYSBURG	PEN	P		6
WRIGHTSVILLE	PEN	V	U	6
YORK TOWNSHIP	PEN	V	U	6
RHODE ISLAND				
NORTH KINGSTOWN	RHI	U		3
WESTERLY	RHI	U		3
SOUTH CAROLINA				
AIKEN	SOC	P		3
ROCK HILL	SOC	P		3
SOUTH DAKOTA				
ABERDEEN	SOD	V	L	3
RAPID CITY	SOD	P		3
SIOUX FALLS	SOD	U		6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
TENNESSEE				
NASHVILLE-DAVIDSON	TEN	V	U	6
TEXAS				
ABILENE	TEX	V	L	1
ALICE	TEX	U		3
AMARILLO	TEX	F		3,4,6
ANSON	TEX	F		6
ARANSAS PASS	TEX	F		6
ARLINGTON	TEX	F		3,6
AUSTIN	TEX	F		3
BEAUMONT	TEX	F		3,6
BEAUMONT	TEX	V	U	6
BELLMEAD	TEX	F		6
BIG SPRING	TEX	F		3
BROWNSVILLE	TEX	F		6
BRYAN	TEX	F		6
BURKBURNETT	TEX	F		6
BURLESON	TEX	F		6
CANYON	TEX	F		6
CASTLE HILLS	TEX	F		6
COLLEGE STATION	TEX	F		6
COLLEYVILLE	TEX	V	U	6
CORPUS CHRISTI	TEX	F		5,6
CORPUS CHRISTI	TEX	V	U	6
DALLAS	TEX	V	L	3,4
DENISON	TEX	F		6
DENTON	TEX	U		3
EDCOUCH	TEX	F		6
EL PASO	TEX	F		6
FARMERS BRANCH	TEX	U		3
FOREST HILL	TEX	F		6
FORT WORTH	TEX	V	L	1,3,4
FRIENDSWOOD	TEX	F		6
GARLAND	TEX	F		1
GRAND PRARIE	TEX	F		3
GRAPEVINE	TEX	F		6
GROVES	TEX	F		6
HAMLIN	TEX	F		6
HARLINGEN	TEX	F		6
HURST	TEX	F		6
LA FERIA	TEX	F		6
LA MARQUE	TEX	F		6
LACY-LAKEVIEW	TEX	F		6
LAKEVIEW	TEX	F		6
LIVE OAK	TEX	V	U	6
LUBBOCK	TEX	F		6
MANSFIELD	TEX	F		6
MCALLEN	TEX	F		6
MCGREGOR	TEX	F		6
MERCEDES	TEX	F		6
MESQUITE	TEX	F		3

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
MIDLAND	TEX	F		5, 6
MINERAL WELLS	TEX	F		3
NEDERLAND	TEX	F		6
ODESSA	TEX	F		1,3,6
ORANGE	TEX	F		6
PEAR RIDGE	TEX	F		6
PHARR	TEX	F		6
PLANO	TEX	F		3
PORT ARTHUR	TEX	F		6
PORT NECHES	TEX	F		6
PORTLAND	TEX	F		6
RICHLAND HILLS	TEX	F		6
ROBINSON	TEX	F		6
SAN ANGELO	TEX	F		6
SAN ANTONIO	TEX	V	Q	1
SAN BENITO	TEX	F		6
SAN JUAN	TEX	F		6
SANSOM PARK VILLAGE	TEX	F		6
SCHERTZ	TEX	F		6
SHERMAN	TEX	V	C,L	3
SHERMAN	TEX	F		6
SINTON	TEX	F		6
SLATON	TEX	F		6
STAMFORD	TEX	F		6
TEMPLE	TEX	F		3
TEXAS CITY	TEX	F		6
TYLER	TEX	F		3, 6
VIDOR	TEX	F		6
WACO	TEX	F		3, 6
WACO	TEX	V	U	6
WEST ORANGE	TEX	F		6
WHITE SETTLEMENT	TEX	F		6
WHITESBORO	TEX	F		6
WICHITA FALLS	TEX	V	L	1
WINDCREST	TEX	F		6
WOODWAY	TEX	F		6
UTAH				
BOUNTIFUL	UTA	F		6
CLEARFIELD	UTA	F		6
FARMINGTON	UTA	F		6
LAYTON	UTA	F		6
MURRAY	UTA	F		6
NORTH OGDEN	UTA	F		6
OGDEN	UTA	F		6
PLEASANT GROVE	UTA	F		6
PROVO	UTA	V	L	1, 3
ROY	UTA	F		6
SANDY CITY	UTA	F		6
SPRINGVILLE	UTA	F		6
WASHINGTON TERRACE	UTA	F		6
WEST JORDAN	UTA	F		6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
VERMONT				
RUTLAND	VER	U		3
VIGINIA				
BRISTOL	VIR	U		4
HARRISONBURG	VIR	U		3
PEARISBURG	VIR	V	C,F	4
PORTSMOUTH	VIR	P		6
WAYNESBORO	VIR	V	C	3
WASHINGTON				
ANACORTES	WAS	V	C,F,L	4
AUBURN	WAS	P		6
BELLINGHAM	WAS	U		2
BOTHELL	WAS	P		6
CLYDE HILL	WAS	V	U	6
DES MOINES	WAS	V	U	6
EVERETT	WAS	V	U	6
ISSAQUAH	WAS	V	U	6
KIRKLAND	WAS	V	C	4
LONGVIEW	WAS	P		3
MARYSVILLE	WAS	P		6
MERCER ISLAND	WAS	V	U	6
MILTON	WAS	P		6
MONROW	WAS	P		6
OLYMPIA	WAS	U		3
PUYALLUP	WAS	P		6
REDMOND	WAS	V	U	6
RENTON	WAS	V	C,L	4
SEATTLE	WAS	P		3
SEATTLE	WAS	V	C	4
SEATTLE	WAS	V	U	6
SNOHOMISH	WAS	P		6
SPOKANE	WAS	V	C,L	5
SPOKANE	WAS	P		6
TACOMA	WAS	V	C,L	1,5
VANCOUVER	WAS	V	C	4
YAKIMA	WAS	V	C,L	1,3
WEST VIRGINIA				
DUNBAR	WEV	P		6
WHEELING	WEV	P		3
WISCONSIN				
BROOKFIELD	WIS	V	U	6
CALEDONIA TOWN	WIS	V	U	6
DELAFIELD	WIS	V	U	6
DUNN TOWN	WIS	V	U	6
EAU CLAIRE	WIS	P		3
ELM GROVE	WIS	V	U	6
GENESEE	WIS	V	U	6
GRAND CHUTE TOWN	WIS	V	U	6
HOWARD	WIS	V	U	6
LISBON	WIS	V	U	6
MEQUON	WIS	V	U	6

(continued)

TABLE A-1 (continued)

CITY	STATE	TYPE OF FEE	BASIS FOR FEE	REFERENCE
MERTON	WIS	V	U	6
MUSKEGO	WIS	V	U	6
NEW BERLIN	WIS	V	U	6
OCONOMOWOC	WIS	V	U	6
PEWAUKEE	WIS	V	U	6
POLK	WIS	V	U	6
RICHFIELD	WIS	V	U	6
SALEM	WIS	V	U	6
SUMMIT	WIS	F		6
VERNON	WIS	V	U	6
WATERFORD TOWN	WIS	V	U	6
WAUKESHA	WIS	V	U	6
WEST BEND	WIS	V	U	6
WYOMING				
CASPER	WYO	F		3
LARAMIE	WYO	V	C	4
ROCK SPRINGS	WYO	F		5
SHERIDAN	WYO	V	F	3

APPENDIX B

MULTINOMIAL LOGIT DEMAND MODEL OF TACOMA

INTRODUCTION

This appendix is taken from a paper delivered by Robert J. Anderson, Jr., of MATHTECH at the Fifth Annual Research Symposium of the Solid and Hazardous Waste Research Division of the Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, at Orlando, Florida, on March 26-28, 1979.

MODEL AND RESULTS

To model the demand for solid waste collection services in Tacoma, I have employed both a multinomial logit model and a regression model. The multinomial logit model is used to characterize choices among the alternative levels of service offered in Tacoma while the regression model is used to explain data concerning total quantities of household waste generated.

Choice Among Alternative Services

Tacoma offers its residents a choice among a number of different collection services distinguished by the number of cans presented for collection and the location with respect to curbside at which these cans are presented. In all, approximately 16 different service levels are offered, ranging from 1 to 6 cans per collection at various distances from curbside. (Virtually no subscribers elected options to have "flight of stairs" service. These options are therefore ignored in my analysis.)

The basic hypothesis on which the statistical model of service selection used here rests is that the probability that any given subscriber will choose a given service level is related to certain attributes of that service level and certain individual characteristics of the subscriber. In the particular case at hand, the service attributes would be such things as its monthly cost, number of cans, and distance from the curb; subscriber characteristics would be such things as family size, income, and other household characteristics.

The available data report the frequency with which subscribers chose the different available services in each of 59 months spanning the period January, 1973 to November, 1977. The schedule of fees for the various available services changed once during this period (in January of

1975), and the charge for collection of extra bags was increased from zero to \$0.75 per bag in May of 1976.

The model used here to characterize service choice data is the multinomial logit model of qualitative choice. This model, as noted above, expresses the probability that an individual will choose a given alternative as a function of the characteristics of the alternative available, the characteristics of the chooser, and interaction terms between alternative and choice-maker attributes. The basic form of the model is as follows:

$$P_{ij} = \frac{e^{\alpha' X_i + \beta_i' Z_j + \gamma_i' W_{ij}}}{\sum_{i=1}^{M} \left(e^{\alpha' X_i + \beta_i' Z_j + \gamma_i' W_{ij}} \right)} \qquad \text{(B-1)}$$

where P_{ij} = the probability that the jth individual will be observed to choose the ith alternative.

M_{ij} = number of alternatives.

α = $K_1 \times 1$ vector of parameters.

X_i = $K_1 \times 1$ vector of attributes of the ith attribute.

β_i = $K_2 \times 1$ vector of parameters.

Z_j = $K_2 \times 1$ vector of attributes of the jth individual.

γ_i = $K_3 \times 1$ vector of parameters.

W_{ij} = $K_3 \times 1$ vector of interaction variables formed from products (or other combinations) of alternative attributes and individual attributes.

This is the general form of the model I have estimated using data on service choices in Tacoma.

Before discussing the precise form of the model estimated and the statistical procedures employed, some explanation of why the multinomial logit model was chosen to characterize solid waste collection service choice may be in order. There are, in fact, two reasons. First, it can be shown that the logit model can be derived from a theory which explains the distribution of choices observed in a population of consumers with differential preferences. In particular, it can be shown that starting with some assumptions about the nature of consumers' preferences and the nature of the random differences that distinguish individual preferences, equation (B-1) can be derived by assuming that consumers choose the most preferred alternative available to them. The probability distribution implied by equation (B-1) may thus be interpreted as predicting the probability distribution of choices that would be made by a population of utility maximizing consumers. Second, among the alternatives available for modeling choice among distinct alternatives, the multinomial logit model is computationally the most tractable. These two factors -- consistency with economic theory and computational considerations -- have led to the choice of the multinomial logit.

Unfortunately, the data available are not adequate to estimate the logit model in its most general form (as shown in (B-1) above). In particular, the data contain no information on the characteristics of individual subscribers in Tacoma that could be matched with subscriber choices among services. My working assumption is thus that the distribution of these characteristics in the population has remained roughly constant over time, and that these characteristics can be treated as a part of the random variation in individual preferences. The remaining explanatory variables in the model are attributes of alternative services, including price, number of cans, and distance from the curb at which cans are placed.

Employing this specification, the unknown parameters of the model have been estimated using the method of maximum likelihood. Estimated parameters and asymptotic t-ratios are shown below in Table B-1. As the results reported in Table B-1 show, the fraction of the total subscriber population choosing any particular service declines with the cost of the service, the number of cans per collection the service provides, and the distance from the curb at which collection is offered. Taken at face value, these results suggest that households prefer lower levels of service (e.g., fewer cans relatively close to curbside), other things being equal. While this result may seem curious at first sight, many investigators have reported that households do not like backyard service (due to noise, spillage, unfamiliar persons in close proximity to the house) and do not care for the space and other management problems posed by additional cans. The negative signs of the coefficients of number of cans and distance from the curb could thus reflect these considerations.

Estimated price elasticities of demand for each of the services corresponding to the parameter estimates shown in Table B-1 are reported below in Table B-2. These estimates exhibit the pattern that elasticities increase with service levels. This is generally what one would expect. At higher levels of service, one has more alternatives to switch to in the face of a price increase. For example, households subscribing to two can service at a distance of between 25 and 75 feet could consider switching to one can service at this distance, to two can service in the curbside zone, or to one can service in the curbside zone. Households subscribing to two can service in the curbside zone can only reduce their service demanded by switching to one can service in the curbside zone.

Taken together, the results reported in Tables B-1 and B-2 suggest that the demand for solid waste collection service levels is sensitive to

TABLE B-1. ESTIMATED PARAMETERS OF MULTINOMIAL LOGIT MODEL

Service characteristic	Coefficient estimate	Standard error	Asymptotic r-ratio	Gradient
Price	-0.486187	5.394209E-03	-90.1312	-599.292
Number of cans	-1.00216	5.685739E-03	-176.259	-227.691
Distance from curb	-0.091494	2.394175E-04	-382.152	-3209.7

TABLE B-2. ESTIMATED PRICE ELASTICITIES USING MULTINOMIAL LOGIT MODEL

Service (number of cans, distance)	Price of service	Share of market	Estimated elasticity of demand
(1,1)	2.45	.7809	0.2610
(2,1)	3.60	.1639	1.4634
(3,1)	4.85	.0328	2.2807
(4,1)	6.00	.0069	2.8970
(5,1)	7.15	.0014	3.4714
(6,1)	8.30	.0003	4.0341
(1,2)	3.90	.0125	1.8724
(2,2)	6.55	.0013	3.1804
(3,2)	9.20	.0001	4.4725
(4,2)	11.85	.0000	5.7613
(1,3)	5.30	.0000	2.5768
(2,3)	9.35	.0000	4.5458
(3,3)	13.40	.0000	6.5149
(1,4)	6.65	.0000	3.2331
(2,4)	12.10	.0000	5.8829
(3,4)	17.55	.0000	8.5326

Distance key:
1 = 0-25 feet
2 = 25-75 feet
3 = 75-200 feet
4 = ≥ 200 feet

service price, and that pricing policy can have a very substantial effect on the number of households subscribing to higher levels of service.

Waste Generation

The results reported in Tables B-1 and B-2 above pertain to choices among the alternative collection services offered by the City of Tacoma. The other equations in my model of the demand for collection services in Tacoma are equations explaining the total quantity of waste generated by households in Tacoma. For these relationships, I have adopted regression equations relating estimated waste generated in Tacoma by households to the price of collection services, income (retail sales is used as a proxy for income), number of subscribers, and season. Three different equations have been estimated, one for each of the components of total waste generation. These three components are total residential collection, litter (which is assumed to be generated by households), and the estimated quantity of waste self-hauled by households for disposal at the city landfill. The estimated equations for each of these components of household solid waste are summarized below in Table B-3.

TABLE B-3. REGRESSION MODEL RESULTS (t-STATISTICS SHOWN IN PARENTHESES)

	log (tons of solid waste collected)	log (tons) of solid waste self-hauled)	log (tons of litter)
Constant	2.2861	20.4863	-6.4047
log(deflated average service price)	-0.1516 (-1.3626)*	0.5350 (1.2344)	-0.7120 (-0.6414)
log(deflated retail sales)	0.0615 (0.3707)	-1.6283 (-2.5182)*	-2.2052 (-1.3314)*
log(number of subscribers)	0.5098 (1.7714)*	0.5658 (0.5046)	3.4908 (1.2154)
Winter months dummy variable	-0.0745 (-2.9772)*	-0.7935 (-8.1399)*	-0.0114 (-0.0456)
Extra bag service dummy variable	-0.0319 (-1.4324)*	0.1690 (1.9458)*	-1.3446 (-6.0437)*
$\overline{R}^2$	0.1576	0.6224	0.5402
F(5,41)	2.721	16.167	11.808
D.W.	2.06	1.70	1.87

* Significant at the 0.10 level.

In broadest terms, the results shown in Table B-3 are consistent with what one would expect. Increases in the price of collection services tend to reduce the quantity of household waste presented for collection and to increase the quantity self-hauled. Collection service price seems to have a small and statistically insignificant negative effect on litter. Note, however, that only in the equation for collection is the price term significant at the 10 percent level.

Because of the fact that the regression equations reported in Table B-3 were estimated in the natural logarithms of the variables shown, each coefficient may be interpreted as an elasticity. Interpreted in this fashion, the regression results imply a relatively low price elasticity of demand for quantity collected with respect to average collection charge of approximately 0.15. If collection charges were increased across the board by 10 percent, approximately a 1.5 percent reduction in quantity of waste presented for collection could be expected, and quantity self-hauled could be expected to increase by about 5.4 percent. Since self-hauling accounts for about 20 percent of household solid wastes and municipal collection accounts for about 80 percent (litter is a negligible fraction), the estimated percentage change in quantity generated associated with a 10 percent increase in price would be approximately zero (i.e., 0.2 x 5.4 - 0.8 x 1.5). This implies that the main effect of increases in the price of solid waste collection services is to increase self-hauling. There is no reduction in quantity of waste generated according to these results.

The coefficients of the proxy used to represent income -- retail sales -- indicate that self-hauling and littering are negatively associated with income levels, and that quantity presented for collection is associated positively (but weakly) with income. The retail sales variable is statistically significant, however, only for self-hauling and littering, with self-hauling and littering decreasing with retail sales.

Increases in the number of subscribers (which is equal to the number of households in Tacoma) results in increases in all three components of the household waste stream. Our estimates for collection and self-hauling (only the coefficient in the collection equation is significant at the 10 percent level) imply that waste has increased less than in proportion to the number of subscribers. Our estimate for littering suggests that this component has increased at over three times the rate of increase of households, other things being equal. As has been suggested above, however, littering is an insignificant portion of the total, and may not have been household litter. In addition, the coefficient of number of households is not statistically significant.

The coefficient of the dummy variable for the winter months indicates that less waste is presented for collection and less is self-hauled during the winter months than during other months of the year. This probably reflects seasonal patterns in household waste generation, particularly with respect to yard wastes.

The coefficient of the dummy variable representing the formal introduction of extra bag service and associated increase in the price of this service in 1976 suggests that the price increase reduced household collection and increased self-hauling, and reduced littering (perhaps by providing a ready means to dispose of temporary excess wastes).

To sum up, the statistical results presented in this section show that the choice of service level is sensitive to price, and that choices are somewhat more responsive to price changes at relatively high service levels. This is, I hypothesize, because there are relatively more substitution alternatives available to households at high levels of service (i.e., they either can reduce the number of cans per collection, or the distance from the curbside at which cans are presented for collection, or they can self-haul). My results also suggest that the quantity of waste generated seems to be relatively insensitive to price. However, the choice between collection and self-hauling does seem to be sensitive to price.

Let me hasten to caution that the results presented are far from conclusive. The data available are relatively rough, and the statistical procedures and assumptions I have made in modeling them by no means are the only ones that could be adopted. If these assumptions or modeling methods were changed, it is quite possible that the results would change also.

CONCLUDING REMARKS

Keeping firmly in mind that all of the statistical results reported in this paper are tentative, it is still useful to discuss the implications for solid waste management which follow from my results. Certainly the strongest implication is that user charges can be used to affect the demand for levels of service. Increasing prices on high service levels seem to result in a reduction in the number of households choosing high service levels. To the extent that provision of high service levels is uneconomic, such a charging policy can increase the economic efficiency of solid waste management.

Some idea of the overall difference in demand for services under a graduated user charges policy, like that employed in Tacoma, and under a flat rate policy distance be gotten by comparing predicted service demands under these two charge systems. This is done in Figure B-1 below, where predicted percentages of subscribers are shown on the vertical axis, and the various can/distance combinations that constitute the available services in Tacoma are shown on the horizontal axis. As can be seen in Figure B-1, the percentage of households subscribing to basic service is estimated to be about 17 percentage points higher under Tacoma's current graduated charge policy (see the diagonally shaded area in Figure B-1). These 17 percentage points reflect a predicted shift away from higher levels of service. The predicted net percentage shifts from each of the higher levels of service are shown by the stippled areas in Figure B-1.

These calculations suggest that the aggregate effect of pricing policy on service level choice may be quite large. If the costs of

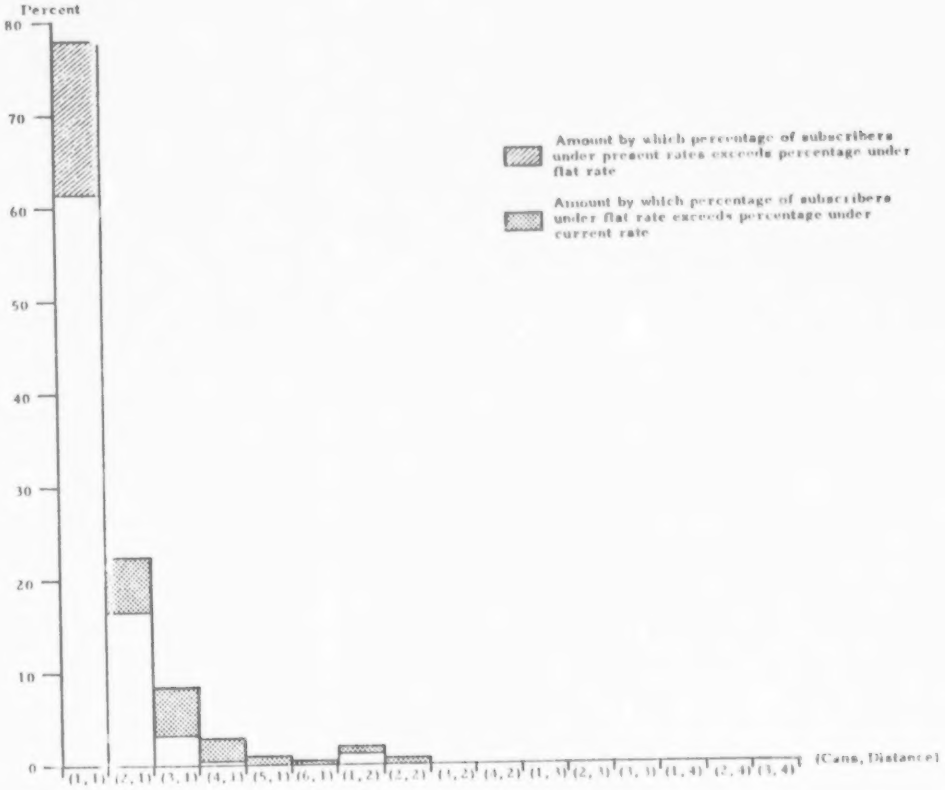

Figure B-1. Percentage of households at each service level under present charge rates and under a flat rate system.

providing higher service levels are large, this suggests that the efficiency gains from adoption of a cost-based pricing policy could be substantial.

A second implication of my results is that service prices have little effect on the quantity of waste generated by households. While my results do show some tendency to reduce tonnage placed for collection, they also show an approximately equal increase in tonnage self-hauled to the landfill.

Overall, these results support the proposition that households' demands for solid waste collection and disposal service are sensitive to price. In addition, these results suggest that the degree of sensitivity may be quite high, and therefore that the solid waste management efficiency gains typically ascribed to a user charge policy that sets charges equal to service costs may be correspondingly great.